6. Water Demand and Water Budget

An important component of water planning is understanding current uses of water and projecting future needs for water. This section examines the current uses of and demands for water in the Jemez y Sangre Water Planning Region, discusses the principles of a water budget and provides water budgets for each sub-basin in the region, summarizes current and projected uses, and compares projected demands to the amount of water available.

6.1 Present Uses and Rights

Water use is reported by the OSE for each county in New Mexico every five years. The OSE tracks water use in New Mexico using the following categories:

- Public water supply and self-supplied domestic
- Irrigated agriculture
- Self-supplied livestock
- Self-supplied commercial
- Industrial
- Mining
- Power
- Reservoir evaporation

Prior to the 1990 OSE inventory, fish and wildlife and recreation were reported as separate categories; beginning in 1990 these categories have been reported as part of the commercial category. Likewise, rural, urban, and military were separate categories until 1990, when they were replaced with the public water supply and self-supplied domestic categories.

Table 20 shows water use by category for the years 1985, 1990, and 1995, based on the OSE inventories for those years (Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997). Data for 2000 have not yet been published. Annual water use data in categories no longer used (fish and wildlife, recreation, rural, urban, and military) have been combined into the current categories in Table 20, which includes data for the entire three-county area. Since not all of Rio

Table 20. Withdrawals in Los Alamos, Rio Arriba, and Santa Fe Counties, 1985, 1990, and 1995
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Category	Withdrawals											
	Surface Water			Groundwater			Total			Percent		
	1985	1990	1995	1985	1990	1995	1985	1990	1995	1985	1990	1995
Los Alamos County												
Public Water Supply	0	0	0	5,541	5,267	5,836	5,541	5,267	5,836	97.2	96.8	98.0
Domestic [a]	0	0	0	3	0	0	3	0	0	0.1	0.0	0.0
Irrigated Agriculture	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
Livestock	5	0	0	0	0	0	5	0	0	0.1	0.0	0.0
Commercial	0	0	0	3	6	1	3	6	1	0.1	0.1	0.0
Industrial	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
Minerals/Mining	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
Power	0	28	4	149	138	115	149	166	119	2.6	3.1	2.0
Reservoir Evap.	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
County Totals	5	28	4	5,696	5,411	5,953	5,701	5,439	5,956	100.0	100.0	100.0
Rio Arriba County												
Public Water Supply	0	433	684	670	1,212	1,601	670	1,645	2,285	0.5	1.4	1.8
Domestic	296	0	0	1,439	1,474	1,748	1,735	1,474	1,748	1.4	1.2	1.4
Irrigated Agriculture	94,194	92,613	89,024	1,076	1,065	886	95,270	93,678	89,910	74.9	77.5	72.0
Livestock	1,696	189	183	200	211	193	1,896	400	376	1.5	0.3	0.3
Commercial	34	106	106	203	143	257	237	249	363	0.1	0.2	0.3
Industrial	0	0	0	4	73	119	4	74	119	0.0	0.1	0.1
Minerals/Mining	0	0	0	852	539	556	852	539	556	0.7	0.4	0.4
Power	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
Reservoir Evap.	26,512	22,863	29,593	0	0	0	26,512	22,863	29,593	20.8	18.9	23.7
County Totals	122,732	116,203	119,589	4,444	4,718	5,360	127,176	120,921	124,949	100.0	100.0	100.0

Sources: Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997

[a] Diversions from domestic wells based on population from 2000 Census indicate much higher values than those reported by Wilson and Lucero.

Table 20. Withdrawals in Los Alamos, Rio Arriba, and Santa Fe Counties, 1985, 1990, and 1995
Page 2 of 2

Category	Withdrawals											
	Surface Water			Groundwater			Total			Percent		
	1985	1990	1995	1985	1990	1995	1985	1990	1995	1985	1990	1995
Santa Fe County												
Public Water Supply	4,266	3,409	5,366	3,508	8,759	10,040	7,774	12,168	15,405	14.4	25.2	30.1
Domestic	0	0	0	2,884	2,611	2,341	2,884	2,611	2,341	5.3	5.4	4.6
Irrigated Agriculture	21,143	19,185	18,808	20,335	13,496	13,596	41,478	32,681	32,404	76.9	67.8	63.3
Livestock	632	135	163	148	160	170	780	295	334	1.4	0.6	0.7
Commercial	0	0	20	376	287	472	376	287	491	0.7	0.6	1.0
Industrial	0	0	0	0	31	61	0	31	61	0.0	0.1	0.1
Minerals/Mining	0	0	0	121	25	9	121	25	9	0.2	0.1	0.0
Power	0	0	0	2	2	2	2	2	2	0.0	0.0	0.0
Reservoir Evap.	518	120	143	0	0	0	518	120	143	1.0	0.2	0.3
County Totals	26,559	22,849	24,499	27,374	25,372	26,692	53,933	48,220	51,191	100.0	100.0	100.0
3-County Totals												
Public Water Supply	4,266	3,842	6,049	9,719	15,239	17,477	13,985	19,081	23,527	7.5	10.9	12.9
Domestic	296	0	0	4,326	4,084	4,089	4,622	4,084	4,089	2.5	2.3	2.2
Irrigated Agriculture	115,337	111,798	107,832	21,411	14,561	14,482	136,748	126,359	122,314	73.2	72.4	67.2
Livestock	2,333	323	346	348	371	364	2,681	694	709	1.4	0.4	0.4
Commercial	34	106	125	582	436	730	616	541	855	0.3	0.3	0.5
Industrial	0	0	0	4	104	180	4	105	180	0.0	0.1	0.1
Minerals/Mining	0	0	0	973	565	565	973	565	565	0.5	0.3	0.3
Power	0	28	4	151	140	117	151	168	121	0.1	0.1	0.1
Reservoir Evap.	27,030	22,983	29,736	0	0	0	27,030	22,983	29,736	14.5	13.2	16.3
3-County Totals	149,296	139,079	144,092	37,514	35,501	38,005	186,810	174,580	182,097	100.0	100.0	100.0

Sources: Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997

[a] Diversions from domestic wells based on population from 2000 Census indicate much higher values than those reported by Wilson and Lucero.

Arriba and Santa Fe Counties are included in the planning region, the usage figures shown in Table 20 are not an exact representation of the planning area. However, the table clearly illustrates that the majority of the water used in the three counties falls within three categories: public water supply, domestic, and irrigated agricultural use. Consequently, the focus of the demand analysis was characterization of withdrawals in these categories for each of the ten sub-basins. Sub-basin withdrawals are presented in Section 6.2, along with sub-basin water budgets

Sections 6.1.1 through 6.1.4 provide brief descriptions of water use in the region for each OSE-defined water use category. Section 6.1.5 discusses existing water rights in the planning region.

6.1.1 Public Water Supply

The Public Water Supply category includes community water systems that rely upon surface and/or groundwater diversions other than private domestic wells and that consist of common collection, treatment, storage, and distribution facilities operated for the delivery of water to multiple service connections (Wilson and Lucero, 1997). Water used for the irrigation of self-supplied golf courses, playing fields, and parks, or water used to maintain the water level in ponds and lakes owned and operated by a municipality or water utility is also included. Inclusion of these uses allows comparison of the total amount of water used by the system to the water rights of public water suppliers, where such rights have been defined. About 25 to 30 percent of the total water used in the planning region is for public water supplies.

6.1.2 Self-Supplied Domestic Wells

This category includes self-supplied residences, which may be single- or multi-family dwellings, with wells permitted by the OSE under Section 72-12-1 NMSA. Typically, domestic wells are not metered and the amount diverted from this supply must be estimated. Estimates vary from a low of 4,000 acre-feet, calculated by OSE as shown on Table 20, to 7,700 acre-feet, as calculated during this planning effort (see Table 22 in Section 6.2.1.2). Though the overall percentage of use is low in this category, it is a growing sector, particularly in Santa Fe County.

Domestic water use in the planning region was developed using the following method. First, an estimate of the total amount of water needed to support the population for one year was estimated by multiplying population by average usage (excluding agricultural usage). Because the average usage in Santa Fe is higher than elsewhere in the region a higher multiplier was used for the Santa Fe Basin. The average per capita usage (commercial, governmental, and residential) was assumed to be 0.15 acre-foot per year (approximately 134 gallons per capita per day [gpcd]) in all sub-basins except the Santa Fe Sub-Basin. For the Santa Fe Sub-Basin, a multiplier of 0.183 acre-foot per year (approximately 163 gpcd) was used for the population on the municipal system and 0.096 acre-foot per year (approximately 86 gpcd) was used for the population on domestic wells; this represents the average per capita annual use in Santa Fe during a non-drought year. The amount of metered usage was then subtracted from the total demand for each sub-basin, and the remainder was assumed to come from domestic wells. Using this method, a total of 7,700 acre-feet of domestic well use is estimated for all sub-basins in the region (Table 22).

6.1.3 Irrigated Agriculture

Wilson and Lucero (1997) define irrigated agriculture as including all diversions of water for the irrigation of crops grown on farms, ranches, and wildlife refuges. Agricultural demand for both withdrawals and consumptive use are not directly measured, but are instead estimated based on a model of crop water needs. Irrigated agriculture is the largest use category in the planning region, responsible for approximately 70 percent of diverted water. Because of a lack of measurement, monitoring, and adjudication of water rights, uncertainties exist regarding (1) the amount of water actually used for irrigation, (2) the number of acres irrigated, (3) the water rights not put to beneficial use, (4) the amount of return flow, (5) priority dates associated with water rights, and (6) how existing water rights might be impacted.

6.1.4 Other Categories

The following use categories make up a small percentage of the overall water used.

- *Self-supplied livestock* includes water used to raise livestock, maintain self-supplied livestock facilities, and provide for on-farm processing of poultry and dairy products (Wilson and Lucero, 1997). Self-supplied livestock represents less than 1 percent of the total water use in the region.

- *Commercial* includes self-supplied businesses (e.g., motels, restaurants, recreational resorts, and campgrounds) and institutions. Self-supplied golf courses that are not watered by a public water supply are also included, as are off-stream fish hatcheries engaged in the production of fish for release. Commercial uses also represent less than 1 percent of the total water use in the region.

- *Industrial* includes self-supplied enterprises engaged in the processing of raw materials or the manufacturing of durable or nondurable goods. Water used for the construction of highways, subdivisions, and other construction projects is also included. Industrial uses represent less than 0.5 percent of the total water use in the region.

- *Mining* includes self-supplied enterprises engaged in the extraction of minerals occurring naturally in the earth's crust, including (1) solids, such as coal and smelting ores, (2) liquids, such as crude petroleum, and (3) gases, such as natural gas. Water used for drilling and/or processing at a mine site is also included. The mining sector is less than 1 percent of the use in the planning region.

- *Power* includes all self-supplied power generating facilities. Water used in conjunction with coal mining operations that are contiguous with a power generating facility that owns and/or operates the mines is also included. The only power plant in the region is the Los Alamos National Laboratory power plant in Los Alamos County, which burns natural gas to produce some 20 megawatts of peaking electricity needed by LANL.

The final category of water use is reservoir evaporation. As indicated in Table 20, reservoir evaporation represents a significant portion of the water demand in Rio Arriba County; however the major reservoirs in the county (Abiquiu, El Vado, and Heron Lakes) lie to the northwest of the planning region.

6.1.5 Water Rights

As discussed in Section 4, two clear principles govern the establishment of water rights in New Mexico:

- Priority of appropriation shall give the better right.
- Water may be used only for beneficial purposes.

An appropriation means dedication of water for a beneficial purpose. Priority of appropriation is often summarized as first in time, first in right. This means that the person who first puts water to use has the senior priority and each additional user has a junior priority. The senior priority holder is entitled to receive the full quantity of water that the senior priority holder can apply to beneficial use or the maximum quantity permitted, whichever is less. Junior priority holders must satisfy uses with the remaining water, in order of their relative seniority. Beneficial use has not been fully defined. Only waste and mine dewatering have been ruled to be a non-beneficial use of water.

6.1.5.1 Surface Water Rights

The types of surface water rights that are applicable to the planning region include those associated with irrigation, municipal use, and livestock water. The OSE maintains the Water Administration Technical Engineering Resource System (WATERS), a water rights database (http://www.seo.state.nm.us/water-info/index.html), but the database does not contain sufficient information to allow an in-depth comparison of water rights with surface water uses. An important distinction exists between the water rights that are administered by the State of New Mexico and water rights that fall under the purview of the federal government, including Pueblo water rights. Pueblo rights, which have priority over state-administered rights and are unending (Chestnut, 2000), remain largely unquantified within the planning region. However, some court-ordered rights have been established for the Pojoaque-Nambe Sub-Basin. More of the Pueblo water rights may ultimately be quantified under an ongoing adjudication (U.S. District Court, 1997) that applies to the Pojoaque-Nambe and Tesuque Sub-Basins (Chestnut, 2000). This adjudication will also clarify non-Pueblo irrigation rights in the sub-basins.

The major municipal surface water right in the region is held by the City of Santa Fe. The Santa Fe River and its storage reservoirs are the surface water supply sources for Santa Fe. The surface water diversion from the Santa Fe River was about 2,819 afy during 1950 and averaged about 3,736 afy from 1950 through 1999. The total surface water right from the Santa Fe River claimed by the City for municipal purposes is 5,040 afy, a value based on the 1976 hydrographic survey for this area. A portion of this right is associated with a City of Santa Fe well known as the St. Michael's well. This well has a maximum permitted pumping rate of 1,000 gallons per minute (gpm) under the license that defines this portion of the surface water right. The City's average annual diversion from the Santa Fe River and St. Michael's well for the period 1990-1999 was 4,637 afy (CDM, 2001).

Water rights in the Santa Fe River Sub-Basin have not been adjudicated. An ongoing adjudication pertaining to the sub-basin (*New Mexico vs. Anaya et al.*) may ultimately lead to a final determination of some quantified water rights for the area (Chestnut, 2000).

The City also holds 131 acre-feet of native Rio Grand rights that are used to offset the pumping of the Buckman well field. Las Campanas has acquired approximately 600 acre-feet of native Rio Grande rights and Santa Fe County is pursuing the purchase of native rights. SJC water is available through a series of contracts to the City and County of Santa Fe, Los Alamos County, the City of Española, and San Juan Pueblo for municipal purposes.

6.1.5.2 Groundwater Rights

The OSE groundwater rights database was used to characterize groundwater rights in the region (Duke, 2001). However, this database is considered incomplete partly because more than 40 percent of the wells listed do not have associated locations or water rights quantities. Also, the water rights database does not account for federal (including Pueblo) water rights in the planning region. As previously mentioned, most Pueblo rights are unquantified. Because of these issues, no clear regional comparison between water rights and water uses currently exists. Regardless, groundwater that is connected to the Rio Grande or its tributaries can only be appropriated if the appropriator acquires sufficient surface water rights to offset surface water pumping.

6.2 Water Budget

The water budget for both surface and groundwater that is presented in this section is based on the Duke water supply study (2001), which provides a more detailed explanation of water budget values and the uncertainty involved in deriving these estimates. The water budget estimates originally prepared by Duke were subsequently updated by the JySWPC. This section discusses the terms and methodology used in the Duke water supply study and then summarizes the surface water and groundwater supply components for each sub-basin, revised with additional information as applicable.

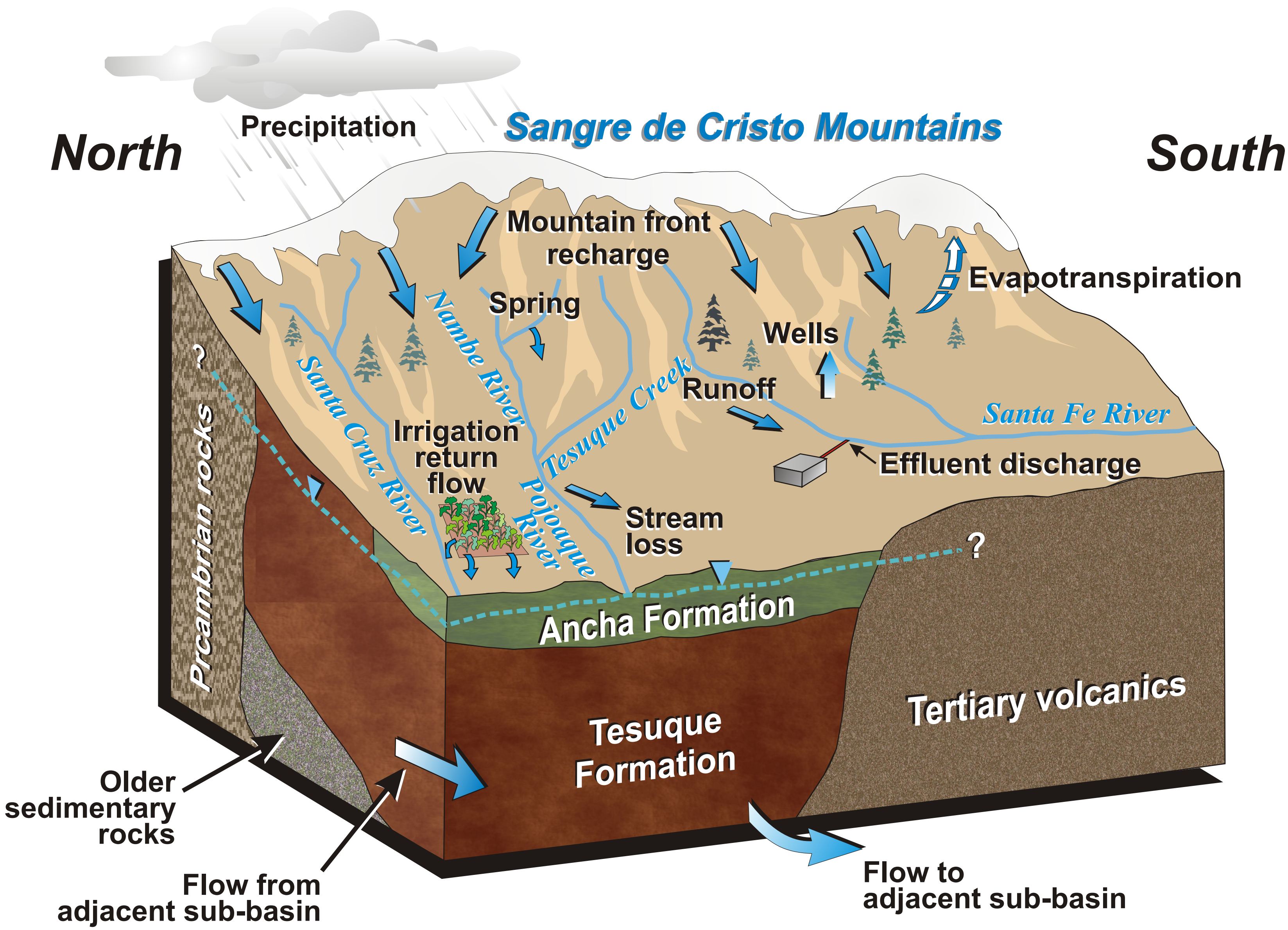
6.2.1 Terms and Methodology

A water budget evaluates the hydrologic balance of an area through describing its inflow, outflow, and storage characteristics. Figure 21 is a schematic diagram illustrating the water budget components for the Jemez y Sangre region.

6.2.1.1 Surface Water Budget Terms and Methodology

Table 21 summarizes the surface water budget for the planning region. This budget is explained in more detail in Sections 6.2.2 through 6.2.11. Terminology used for describing the surface water budget is defined below.

Surface-water inflow is the amount of water that annually enters the sub-basin as surface runoff. The exact method used to evaluate this component varies depending on the characteristics of the sub-basin for which it is being determined. In the Santa Cruz, Pojoaque-Nambe, Tesuque, and Santa Fe River Sub-Basins, surface-water inflow refers to the amount of runoff occurring at the mountain-front, which, in this study, is defined as the lowest elevation at which crystalline rocks outcrop. In the Velarde Sub-Basin, surface-water inflow is defined as the combined flow entering the sub-basin from the Rio Grande and mountain-front runoff. In the Santa Clara and Los Alamos Sub-Basins, inflow represents the runoff generated near the eastern-most extent of lava flows on the Pajarito Plateau. Surface-water inflows to the Caja del Rio and North Galisteo Creek Sub-Basins were estimated for the entire surface area of each. In the South Galisteo



JEMEZ Y SANGRE REGIONAL WATER PLAN
Water Budget Components

Figure 21

**Table 21. Surface Water Budgets by Sub-Basin
Jemez y Sangre Water Planning Region**

Sub-Basin	Velarde	Santa Cruz River	Santa Clara	Los Alamos	Pojoaque -Nambe	Tesuque	Caja del Rio	Santa Fe River	North Galisteo Creek	South Galisteo Creek	Total
Inflow (afy)											
Surface inflow	593,580	26,280	5,570	2,790	10,540	3,500	1,350	7,850	900	6,240	658,600
Springs	5,800	0	0	0	4,000	1,815	0	2,170	0	890	14,675
Return flow irrigation	16,750	10,760	885		4,460	1,115	0	1,560	0	170	35,700
Return flow municipal	0	0	0	0	0	0	0	6,500	0	0	6,500
Total inflow	616,130	37,040	6,455	2,790	19,000	6,430	1,350	18,080	900	7,300	715,475
Outflow (afy)											
Irrigation	26,400	19,705	1,625	0	8,440	2,110	0	2,665	0	285	61,230
Municipal	0	0	0	0	0	0	0	4,625	0	0	4,625
Seepage	1,800	5,190	510	400	5,000	2,500	1,150	8,500	770	0	25,820
Evapotranspiration	2,570	3,680	550	1,990	2,850	1,280	200	1,180	130	2,570	17,000
Surface outflow	585,360	8,470	3,780	400	2,705	540	0	1,110	0	4,440	606,805
Total outflow	616,130	37,045	6,465	2,790	18,995	6,430	1,350	18,080	900	7,295	715,480

Source Duke, 2001 (Table 3-14).
afy = Acre-feet per year

Creek Sub-Basin, surface-water inflow was assumed to equal the runoff generated above an elevation of 6,500 ft msl.

Wherever possible, stream-gage data were used to estimate surface-water inflow. In most sub-basins, however, streamflow gaging stations do not coincide with the locations (identified above) where inflow is determined. Thus, most of the inflow estimates were developed using the elevation-area-yield approach (Reiland, 1975).

Stream gain is the amount of water that flows into the stream from springs or seeps from an aquifer, while *stream loss* is the amount of water that seeps out of the stream and recharges the aquifer. Data for this gain or loss were not well quantified, and consequently Duke estimated this amount as the residual from all of the other budget components. In a few sub-basins the gain or loss was estimated directly if (1) stream-gage data were available, (2) measured spring flow data were available, or (3) estimates of stream-aquifer exchange quantities were available from separate sources.

Total *evapotranspiration* in a sub-basin represents combined FWS evaporation and ET from riparian areas where the water table is assumed to be, on average, quite shallow (less than 20 feet below ground surface). The FWS evaporation outflows from streams, canals and reservoirs were developed by multiplying the surface areas of perennial water bodies by an average evaporation rate of 45 inches per year (in/yr). Estimates of ET losses from riparian corridors were developed by multiplying riparian surface areas by representative PET rates. Landsat imagery provided by Santa Fe County for land use in 1992 was used to delineate the riparian areas.

A surface water *diversion* is the amount of water removed from a stream for human use (e.g., irrigation or drinking water). Irrigation diversions were estimated by multiplying an irrigated acreage value by an irrigation application rate that varied with each sub-basin. The surface water budget shows the amount of water diverted from the stream as opposed to the amount of water actually consumed. The amount of water that is not consumed through crop ET or other incidental depletions either returns to the stream system or recharges groundwater.

Water that returns to the system is called *return flow* water. Return flows consist of (1) irrigation applications that initially seep into the ground and recharge the aquifer but eventually return to a natural watercourse through springs and seeps and (2) surface flow in canals and acéquias that returns to a watercourse.

Several sources were considered for estimating irrigated acreage in the various sub-basins. These included (1) the planning office of Rio Arriba County, (2) Wilson and Lucero (1997), (3) 1992 Landsat imagery, and (4) hydrographic surveys for various parts of the region. The Duke study compared the irrigated acreages determined by each source and revealed large discrepancies between the estimates. This uncertainty in actual water use poses a problem for water planning. Without a complete adjudication of the region, this problem will remain. The estimates of irrigated acreage determined from the three methods were presented in Section 5 (Tables 13 and 14).

Surface water diversions for municipal use in the Santa Fe River Sub-Basin were estimated using records of measured flows. The average of annual Santa Fe River diversions for urban use between 1990 and 1999 was used to develop the budget for this sub-basin.

6.2.1.2 Groundwater Budget Terms and Methodology

Table 22 summarizes the groundwater budget for the planning region. Sections 6.2.2 through 6.2.11 explain this budget in greater detail. The terms and methodology used to estimate groundwater budget components are described below.

In a groundwater budget, the total inflow and outflow components are not equal when water levels are either rising or falling. If outflow is greater than the inflow, water levels will lower in the aquifer and the volume of water in storage will decrease. Where the *change in storage* is negative, water levels in the sub-basin are dropping, and where the value is positive, water levels are rising. It is possible to have water levels dropping in one location and rising in another within the same sub-basin, as is the case in the Santa-Fe River Sub-Basin. Recharge from the effluent from the wastewater treatment plant is causing water levels to rise in the reach from the Santa Fe Airport to the Rio Grande, yet water levels in the vicinity of the City have dropped hundreds of feet over the last 50 years.

Table 22. Groundwater Budgets by Sub-Basin
Jemez y Sangre Water Planning Region

Sub-Basin	Source [a]	Velarde	Santa Cruz River	Santa Clara	Los Alamos	Pojoaque-Nambe	Tesuque	Caja del Rio	Santa Fe River	North Galisteo Creek	South Galisteo Creek	Total
Inflow (afy)												
Mountain front recharge	Duke	2,100	3,080	3,760	3,820	4,500	2,460	0	5,050	0	5,500	30,270
Stream loss	Duke	1,800	5,190	510	400	5,000	2,500	1,150	1,600	770	0	18,920
Stream loss below La Bajada	Duke	---	---	---	---	---	---	---	4,730	---	---	4,730
Flow from adjacent sub-basins	Duke	4,500	1,760	0	0	3,800	3,500	3,550	1,000	1,550	1,050	20,710
Return flow [b]		380	1,620	850	180	610	365	0	3,320	830	215	8,370
Total inflow		8,780	11,650	5,120	4,400	13,910	8,825	4,700	15,700	3,150	6,765	83,000
Outflow (afy)												
Municipal wells	Duke	0	200	970	4,010	0	0	4,910	2,265	405	0	12,760
Other metered wells	Wilson & Lucero	250	90	0	0	95	105	---	765	130	140	1,575
Domestic wells [c]	BBER	500	2,825	150	0	845	620	85	1,275	1,125	295	7,720
Irrigation wells	Duke	45	0	0	0	365	0	0	320	0	0	730
Evapotranspiration	Duke	1,350	2,400	1,250	300	1,850	2,400	1,100	1,200	500	1,300	13,650
Springs	Duke	5,800	0	0	0	4,000	1,815	0	2,170	0	890	14,675
Outflow from sub-basin	Duke	800	7,130	2,740	2,300	6,960	4,000	2,550	4,120	2,050	4,600	37,250
Total outflow		8,745	12,645	5,110	6,610	14,115	8,940	8,645	12,115	4,210	7,225	88,360
Change in storage [d]		35	-995	10	–2,210	–205	–115	–3,945	3,585	–1,060	–460	–5,360

[a] Sources: Duke, 2001 (Tables 5-9 and 5-6); Wilson and Lucero, 1997; BBER, 2000; BBER, 2002. afy = Acre-feet per year --- = Not available

[b] Calculated from revised domestic well diversions using the same methods employed by Duke (2001).

[c] The amount of water diverted from domestic wells was estimated by multiplying the population of all sub-basins by 0.15 acre-foot (except Santa Fe, for which 0.183 acre-foot was used) per capita to obtain an estimate of the total amount of water needed to support the population. The amount of metered usage was then subtracted from the total, and the remainder was assumed to come from domestic wells.

[d] Inflow minus outflow

The inflow components of the groundwater budget consist primarily of various mechanisms of recharging an aquifer and the inflow that occurs from one sub-basin to another. Recharge from stream losses and mountain-front recharge are the two natural mechanisms for recharge (Figure 21). Areal recharge from precipitation in areas other than mountain fronts is considered by many researchers to be very small and assumed to be zero in water budgets for the region.

Recharge from stream losses is equivalent to stream seepage, an outflow component of the surface water budget. In areas where the aquifer water level is below the stream level, the stream loses water and the aquifer is recharged. The amount of recharge depends on the flow in the stream, the amount of clay on the bottom of the stream, and the type of geologic formation that separates the stream and the aquifer. As stated earlier, without stream gaging, this amount is estimated as a residual in the water budgets of most sub-basins in the region.

Mountain-front recharge consists of sub-surface flow across the interface between basin sediments and the igneous rocks that are found on the eastern and western margins of the Española Basin. Because mountain-front recharge has not been measured directly, it, like groundwater/surface water exchange, is considered one of the most uncertain water budget components. Mountain-front recharge was estimated as the remainder of precipitation minus evaporation and runoff. Using mass balance techniques involving annual volumes of precipitation, evaporation, and surface runoff from the mountains, Duke developed separate estimates of mountain-front recharge for each of the sub-basins in the Jemez y Sangre Water Planning Region. To produce the estimates, the mountain front along the eastern side of the planning region was delineated as the contact line between the crystalline rocks of the Sangre de Cristo Range and sediments of the Santa Fe Group. The mountain front along the western side of the planning region was delineated as the contact line between the volcanic rocks of the Jemez Mountains and the sediments of the Santa Fe Group.

Average precipitation in the mountains was estimated using the precipitation map developed by Wasiolek (1995), and the PET map prepared by Tuan et al. (1969) was used to estimate the PET for each sub-basin. Representative values for both precipitation and PET volumes were developed for the mountainous parts of each sub-basin via weighting of areas between contours of these variables (i.e., the area between contours was estimated and multiplied by the average value between contours).

The surface runoff volume associated with mountainous areas in each sub-basin was estimated using either the area-elevation-yield approach of Reiland (1975) or gaging station data. A total of about 27.5 cubic feet per second (cfs) (19,940 afy) is estimated to recharge the regional aquifer system via mountain-front sources in the Sangre de Cristo Mountains. The estimated subsurface inflow from the mountain front along the Jemez Mountains is about 10.5 cfs (7,600 afy).

Flow from adjacent sub-basins is the water that flows underground across sub-basin boundaries. The flow into one basin is equivalent to the flow out of another basin. The methodology for calculating the flow is described below.

Return flow to groundwater was estimated from the Wilson and Lucero (1997) estimated rates of return flow for diversions. Return flow from septic tanks was estimated as 50 percent of the amount diverted from domestic wells. The return flow values provided in Table 22 differ from the values presented by Duke (2001, Table 5-9) because the estimates of diversions from domestic wells and other metered wells was modified due to revised population estimates. The return flow for municipalities varied, based on data from Wilson and Lucero (1997). For the City of Española, the return flow was 80 percent of the diversion, while Los Alamos' return flow was estimated by Duke (2001) to be 4 percent of the diversion, largely because much of the Los Alamos water is consumed in the industrial processes at LANL and in reuse through turf application. However, diversion records for 2001 and 2002 indicate that return flow in Los Alamos may be closer to 30 percent. In Santa Fe, Duke reported the return flow to groundwater from effluent (2,170 acre-feet) as stream loss; Table 22 incorporates this into return flow to groundwater. This return flow occurs between the wastewater treatment plant and La Cienega. The return flow from the Eldorado community system is estimated as 50 percent of the diversion. The return flows from irrigation are included in the estimates for Velarde, Pojoaque-Nambe, and Santa Fe River Sub-Basins.

The groundwater outflow components consist of both natural and man-induced mechanisms. Groundwater discharges naturally to the Rio Grande and its tributaries where the water level in the aquifer is higher than the stream. Groundwater can also flow out of one sub-basin into another sub-basin. Other natural processes for groundwater loss include evapotranspiration from a shallow water table and discharges to springs. Groundwater pumping through wells is a man-induced groundwater discharge.

Groundwater discharge across sub-basin boundaries is categorized as the *outflow from sub-basin*. Considerably large groundwater flows occur between basins. Estimates of interbasin flow were developed using Darcy's Law and appropriate hydrologic parameters. These initial values were then adjusted to account for other influences on the transfer of water such as possible vertical gradients and deeper aquifer thicknesses in some locales.

In locations where the ground elevation intersects the water level elevation, groundwater discharges to *springs* or seeps and flows to the Rio Grande or its tributaries. The amount of groundwater discharge to surface water is equal to the surface water inflow discussed in Section 6.2.1.1 and is estimated as the residual of the surface water budget, except where specific data are available.

Groundwater discharged through ET occurs when the roots of trees or other vegetation tap the aquifer and consume water directly from the aquifer. Groundwater discharge to ET was estimated for areas with a depth to groundwater of 20 feet or less. This estimate was not intended to overlap with other estimates of water loss to the atmosphere such as losses due to ET by irrigated crops and ET riparian vegetation. Consequently, this discharge component was ascribed to locales away from known irrigated and riparian areas. A depth to groundwater of 20 feet or less was chosen as the depth at which losses to ET could occur, based on the fact that phreatophyte trees typically have rooting depths of about 33 feet (Bouwer, 1978) and phreatophyte shrubs commonly root to a depth of 10 feet.

A depth-to-groundwater map was used to estimate the acreage where the depth to the water table was less than 20 feet, and this was multiplied by an ET rate estimated by subtracting the mean annual precipitation for the area from the sub-basin PET rate. A total of about 13,650 afy was estimated for groundwater discharged through ET for the entire planning region.

Pumping of groundwater in the planning region is mainly for municipal and domestic uses. A small amount of groundwater (about 730 afy) is diverted for irrigation use. Estimates of diversion for this component were revised from Duke (2001) based on updated population estimates, a compilation of metered wells provided by Wilson and Lucero (1997), and the municipal pumping records for Los Alamos, Española and the City of Santa Fe.

Community wells, including municipal wells, are individually metered and are required to report usage to the OSE. Annual production from municipal wells is provided in Duke (2001); the quantity diverted from community wells is reported by Wilson and Lucero (1992, 1997).

The amount of water diverted from domestic wells was estimated indirectly, since domestic wells are generally not metered. The population estimate for the year 2000 was multiplied by 0.15 acre-foot per person per year (approximately 134 gpcd) for each sub-basin (except Santa Fe) to obtain the total amount of water needed to support the population. The amount of measured (metered) usage was subtracted from this amount to obtain the residual quantity that is assumed to be met through domestic wells. The 0.15 acre-foot per person includes all non-agricultural uses of water in each sub-basin. The domestic wells in sub-basins without municipal systems are likely to serve businesses such as gas stations, restaurants, etc. in addition to the domestic usage.

For the Santa Fe River Sub-Basin, the rate of water use per person on the City water system is 0.183 acre-foot per person when no drought restrictions are in place. (This value reflects a reduction in water usage from 0.23 acre-foot per person per year, which was the usage rate prior to the implementation of the conservation ordinance that restricts watering from 10 a.m. until 4 p.m. during the summer months.) To obtain the amount of water derived from domestic wells in the Santa Fe River Sub-Basin, the population for 2000 was multiplied by 0.183 acre-foot per person per year (approximately 163 gpcd) and the amount of metered usage was subtracted to obtain a volume for the demand not supplied by a water system. This residual was then divided by 0.183 acre-foot per person to obtain the population supplied by individual wells. The population using individual wells was multiplied by 0.096 acre-foot per person to obtain a reasonable estimate for the amount of water diverted from domestic wells for domestic use only.

The groundwater budgets are highly uncertain. Many of the components have been developed using the principle of mass balance, in which the summed components of groundwater inflow are expected to equal the sum of outflow components and rates of change in groundwater storage. However, the estimated budget components should be tested to determine if they are mathematically consistent with measured hydraulic heads and/or measured stream/aquifer exchanges in a three-dimensional environment. To determine such consistency, numerical models that are capable of simulating three-dimensional groundwater flow are most useful. If a numerical model is developed with enough detail to facilitate the quantification of various groundwater flow processes on a relatively local level, it should ultimately provide much better estimates of budget components such as interbasin subsurface flow, vertical groundwater movement, and stream-aquifer interaction.

6.2.2 Summary of Water Budget Components for Velarde Sub-Basin

Surface water inflow to the Velarde Sub-Basin consists primarily of Rio Grande flow at Embudo, and runoff from the Sangre de Cristo Mountains east of the river. Runoff from the west side of the river in the vicinity of Black Mesa is imperceptible within the total sub-basin budget.

The average annual flow at the Embudo Gage for the years 1963 to 1986 (591,160 afy) was used to compute part of the area's surface water inflow. Tributary inflow (2,420 afy) was derived using the elevation-area-yield approach, which accounts for ET losses.

Irrigated acreage is concentrated along the Rio Grande and along reaches of the Rio de Truchas. Approximately 26,400 afy of surface water and 45 afy of groundwater are used for irrigation purposes within the Velarde Sub-Basin. Reported 1995 irrigated acreage in the area was used to estimate irrigation diversions, depletions, and return flows. Free water surface evaporation losses from the Rio Grande channel of 2, 570 afy were estimated assuming a river width of 100 feet over a river stretch of 16 miles (from Embudo to the watershed outlet). ET losses near the Rio Grande and Rio de Truchas areas were computed using an estimated riparian acreage of about 1,000 acres, as measured from the 1992 Landsat map.

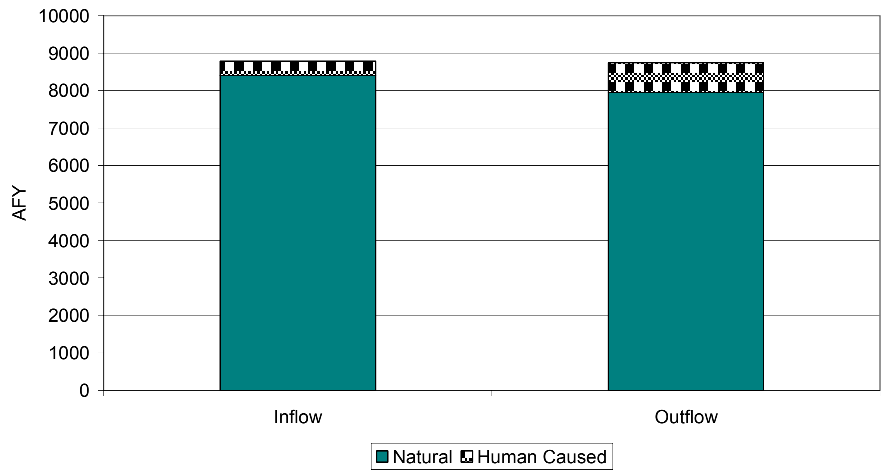
Inflow from groundwater to surface water along the Rio Grande has been estimated at about 0.5 to 1.0 cfs per river mile. For the 16 miles between Embudo and the San Juan Pueblo, the Rio Grande was assumed to gain inflow from groundwater discharge at a rate of 0.5 cfs per mile, resulting in a total annual river gain of 5,800 afy.

The remaining budget component, loss of surface water to groundwater, was estimated at 1,800 afy by comparing all components. The outflows to groundwater are assumed to occur in areas of the sub-basin at higher elevations than the Rio Grande.

Assessment of the surface water budget indicates that surface water is considered fully appropriated in the Velarde Sub-Basin. However, Pueblo water rights remain to be determined. There appears to be sufficient flow in the main stem of the Rio Grande for agricultural purposes during 10-year drought and minimum flow conditions. Surface water use off the main stem at higher elevations in the sub-basin would likely be impacted during periods of drought.

Assessment of the groundwater budget indicates that groundwater resource is extensive and largely not utilized in the Velarde Sub-Basin. Figure 22 shows the inflow and outflow from natural and man-caused components for the water budget. The comparison of estimated inflows to outflows indicates that the groundwater appears to be in a state of equilibrium and that little change in storage is occurring. The estimated groundwater storage in the aquifer is 9.6 million acre-feet. However, because surface waters are fully appropriated, stream-connected groundwater appropriations or transfers will be conditioned to require retirement of surface water rights to offset any depletions caused by groundwater pumping.

Domestic supplies are provided through mutual and individual domestic water supply wells. Approximately 750 afy of groundwater is pumped for municipal/domestic and industrial purposes.



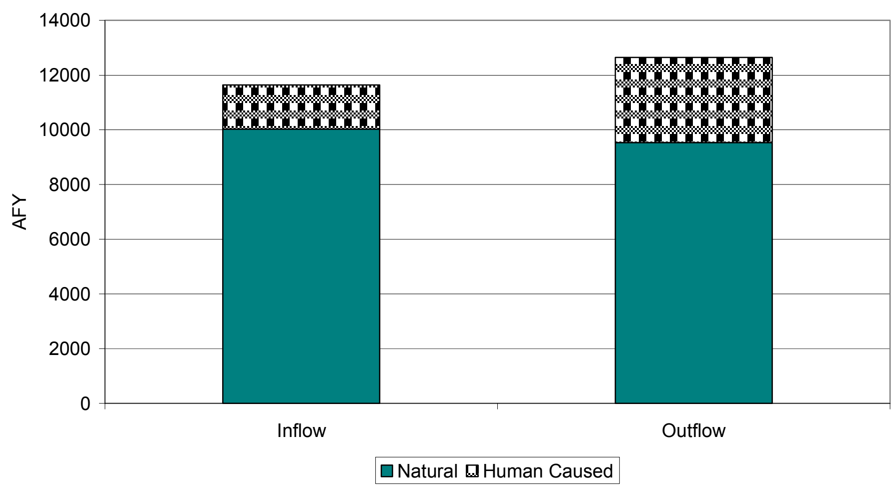
Annual Groundwater Budget for the Velarde Sub-Basin (1995)

Figure 22

6.2.3 Summary of Water Budget Components for Santa Cruz Sub-Basin

Surface water inflow from the combined drainage areas of the Rio Medio, Rio Frijoles (using gaging station data) and Rio Quemado (using the elevation-area-yield approach) at the mountain front is estimated to be 26,280 afy. Inflow from groundwater (springs and seeps) is assumed to be negligible because a net stream loss is computed for the Santa Cruz Sub-Basin. Surface water is used primarily for agricultural purposes with an estimated 19,705 afy diverted for 9,890 irrigated acres (using the method of Wilson and Lucero 1997, but also noting considerable uncertainty) in the sub-basin. Return flow from irrigation is estimated to be 10,760 afy. Stream losses (to groundwater) are estimated to be 5,190 afy for all streams in the sub-basin based on the residual of all other surface water budget components. Water losses to evaporation (from 132 acres of stream channel and reservoir surface area) and ET (from 2,000 acres of riparian area) results in a total loss estimated at 3,680 afy. Surface water outflow to the Rio Grande averages 8,470 afy, which includes the Santa Cruz watershed as measured at a gauging station near Riverside and estimated yields (using the Reiland [1975] method) from Arroyo Seco and Arroyo Madrid.

The amount of water recharging the aquifer in the Santa Cruz Sub-Basin is nearly 1,000 afy less than the amount of water leaving the basin, indicating that the aquifer is being mined as shown in Figure 23. The total inflow to groundwater is estimated to be 11,650 afy, including 3,080 afy from mountain-front recharge, 5,190 afy from surface water infiltration along stream courses, 1,760 afy from adjacent sub-basins, and 1,620 afy from return flow of irrigation and municipal/industrial sources.



Annual Groundwater Budget for the Santa Cruz Sub-Basin (1995)

Figure 23

Groundwater outflow is estimated to be 3,115 afy for domestic and municipal use, 2,400 afy to ET and 7,130 afy to outflow from the sub-basin. Groundwater is tapped primarily for rural domestic use and by the City of Española for municipal uses.

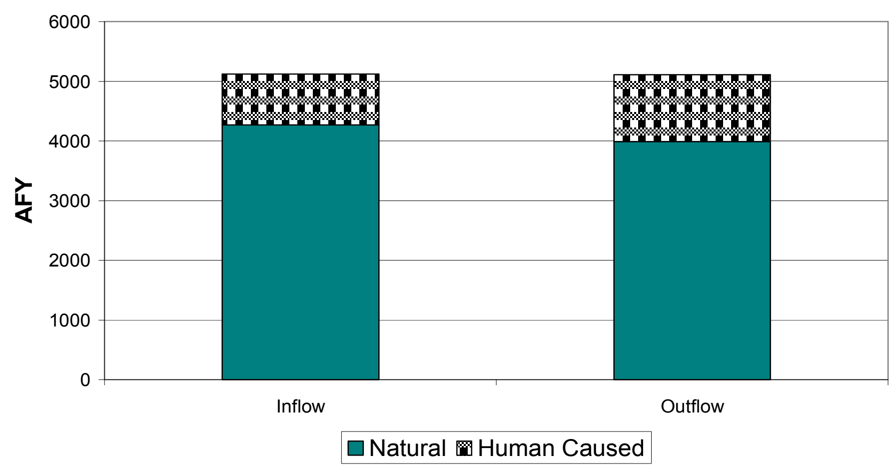
6.2.4 Summary of Water Budget Components for Santa Clara Sub-Basin

Inflow from rain and snowmelt runoff for the Santa Clara Sub-Basin was calculated at 5,570 afy using the elevation-area-yield approach of Reiland (1975). The stream loss to groundwater of 510 afy is considered a highly uncertain estimate because it is calculated as a residual after comparing all other water budget components. Evaporation and ET losses of 550 afy were estimated using a riparian area of 310 acres. Surface water diversions for the 700 acres of irrigated land (based on Rio Arriba County planning documents) is approximately 1,625 afy, according to application rates published by Wilson and Lucero (1997). The diverted irrigation water is estimated to yield a return flow of about 885 afy.

Surface water flow into the Rio Grande is estimated to be 3,780 afy using flow measurements on Santa Clara Creek near Espanola and yields for ephemeral tributaries estimated by the elevation-area-yield method (Reiland, 1975).

Total groundwater inflows and outflows are essentially equal, as shown in Figure 24, indicating little change in the amount of water from storage in this sub-basin. Total groundwater inflow is estimated at 5,120 afy, with 3,760 afy from mountain front recharge, 510 afy from stream channel recharge, and 850 afy from return flow, mostly from irrigation water.

Total groundwater outflow is estimated to be 5,110 afy, with 1,120 afy going to municipal use by Santa Clara Pueblo and adjacent communities south of Española and domestic uses, 1,250 afy to ET (to a depth of 20 feet), and 2,740 afy to groundwater moving slowly (underground) out of the Santa Clara Sub-Basin into adjacent sub-basins.



Annual Groundwater Budget for the Santa Clara Sub-Basin (1995)

Figure 24

6.2.5 Summary of Water Budget Components for Los Alamos Sub-Basin

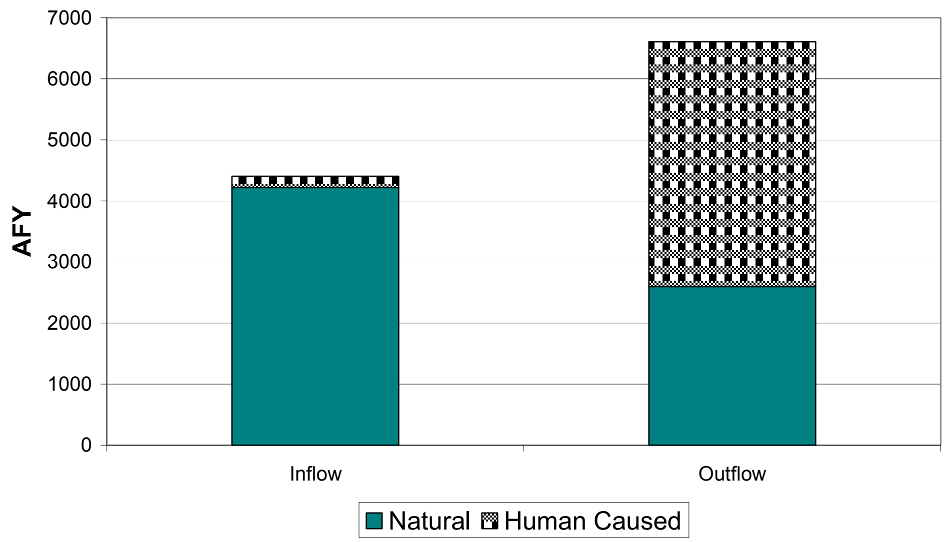
Surface water inflow at the mountain-front in the Los Alamos Sub-Basin was estimated at 2,790 afy using the elevation-area-yield approach, which accounts for terrestrial ecosystem ET losses. Runoff, spring discharge from perched aquifers, and sanitary wastewater discharges enhance surface water flows. Using estimates of flat free water surface areas and riparian areas, total ET was estimated to consume 1,990 afy of surface water.

Stream losses on the plateau are significantly greater than can be explained by ET and thus represent a source of recharge for the groundwater system. This mechanism, however, probably produces far less water than does recharge from the Sierra de los Valles and possibly from Valles Caldera. Assessment of the surface water budget indicates that surface waters are not used for human purposes, thus the system is in a natural state.

The regional aquifer beneath the Pajarito Plateau occurs in rocks of the Puye Formation, Cerros del Rio Basalts, and Tesuque Formation. The aquifer is unconfined in the west and confined in the east near the Rio Grande. The flow of groundwater is east or southeast, toward the Rio Grande.

The Rio Grande is the main discharge area for the regional aquifer. The aquifer primarily is recharged by underflow of groundwater from the Sierra de los Valles. However, there is leakage from alluvial groundwater in canyon bottoms on the Pajarito Plateau, and from intermediate perched groundwater.

Groundwater is the sole source of supply for Los Alamos municipal, domestic, and industrial purposes (approximately 4,000 afy). Assessment of the groundwater budget indicates net depletion of groundwater due to pumping could be as little as zero or as large as 2,000 to 3,000 afy, depending on assumptions about recharge rates. Figure 25 shows the estimated balance according to Duke (2001). It is unclear whether municipal pumping has reduced discharge to the Rio Grande. Ongoing studies indicate water levels in the aquifer may be stabilizing and current pumping rates may be sustainable. Estimated groundwater storage is 11 million acre-feet. However, because surface waters are fully appropriated, stream-connected groundwater appropriations or transfers will be conditioned to require retirement of surface water rights to offset any depletions caused by groundwater pumping. The long-range water supply plan for Los Alamos County indicates the water level declines between 1 and 2 feet per year within the 500- to 1,500-foot-thick saturation zone of the aquifer.



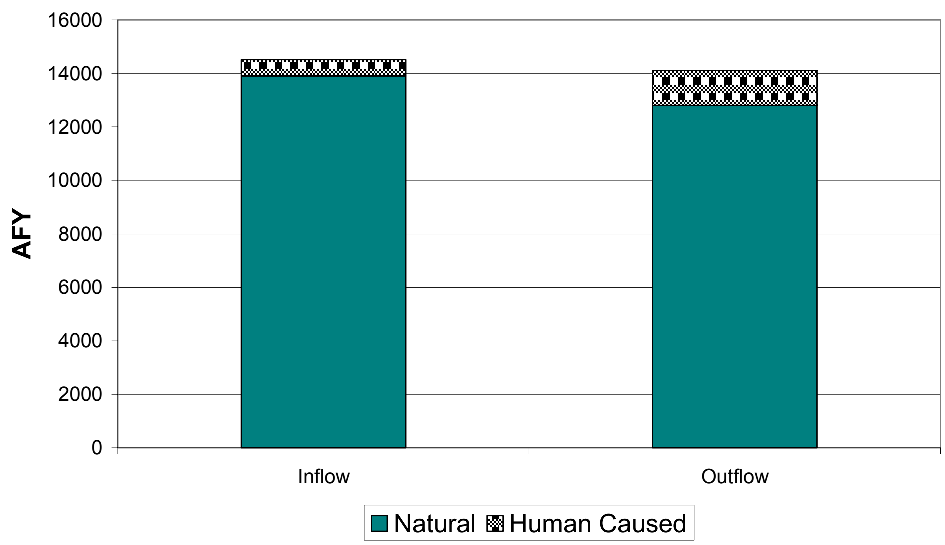
Annual Groundwater Budget for the Los Alamos Sub-Basin (1995)
Figure 25

As recognized by the OSE, Los Alamos County administers a water right of 5,541 afy. On average, approximately 80 percent of the right has been used over the past 10 years. The County holds a 1,200 acre-foot San Juan/Chama contract, which could potentially allow diversion and consumption of up to 1,550 afy. According to the Los Alamos County Long Range Plan, present County development plans could result in an 11 percent increase in water usage. Additional water use by LANL is more difficult to forecast, but likely to remain stable because of aggressive water conservation efforts.

6.2.6 Summary of Water Budget Components for Pojoaque-Nambe Sub-Basin

The surface water inflow for the Pojoaque-Nambe Sub-Basin was estimated to be 10,540 afy based on multiple investigations and the outflow calculated for the Tesuque Sub-Basin (Section 6.2.7). Surface water diversions in the sub-basin total 8,440 afy for 1,900 irrigated acres (Wilson and Lucero, 1997). Irrigation return flow is estimated to be 4,460 afy to surface water. Evaporative losses are estimated to be 2,850 afy based on 120 acres of open water surface and 1,365 acres of riparian vegetation. Stream seepage losses of 5,000 afy were estimated from data reported by Frenzel (1995). The surface water outflow of 2,705 afy is estimated as a residual of all other surface water budget components, but compares favorably to the 2,650 afy reported in the Aamodt water rights case Findings of Fact (U.S. District Court, 1997).

The amount of recharge the aquifer in the Pojoaque-Nambe Sub-Basin appears to be somewhat less than the amount that is discharged from the basin; however, the difference is small in comparison to the total estimated flows, as shown in Figure 26. Total estimated inflow to the groundwater is 13,910 afy, including 4,500 afy from mountain-front recharge, 5,000 from seepage of streams and rivers, and the remainder from other factors. Groundwater diversions are estimated at 1,310 afy with about 940 afy used for domestic purposes, and the remainder for irrigation. Springs contribute about 4,000 afy to rivers and streams; subsurface outflow is 6,960 afy and ET accounts for 1,850 afy.



Annual Groundwater Budget for Pojoaque-Nambe Sub-Basin (1995)
Figure 26

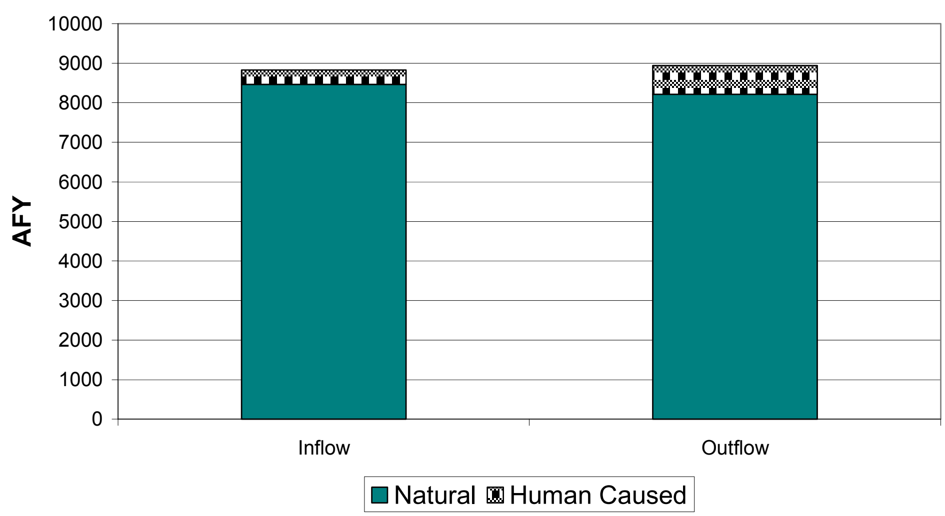
6.2.7 Summary of Water Budget Components for Tesuque Sub-Basin

The surface water budget for the Tesuque Sub-Basin includes an estimated 3,500 afy inflow from the combined drainage area of Tesuque and Little Tesuque Creeks and their ephemeral tributaries, based on the elevation-area-yield approach. Inflow from groundwater adds 1,815 afy based on water level elevations and the residual from all other water budget components.

Return flow from irrigation sources is estimated to be 1,115 afy, yielding a total estimated inflow of 6,430 afy. Total outflow is estimated at 6,430 afy. This includes 2,110 afy to irrigation (475 acres of irrigated land), 2,500 afy to stream losses to groundwater, 1,280 afy to ET (from 80 acres of open surface water area and 540 acres of riparian area), and 540 afy as flow into the Pojoaque River.

The total amount of recharge to the groundwater in the Tesuque Sub-Basin is slightly less than the amount of discharge, indicating that some amount of water may be derived from storage, as shown in Figure 27. Groundwater budgets for the Tesuque Sub-Basin include a total estimated inflow of 8,825 afy, including inflow from mountain front recharge of 2,460 afy, stream channel recharge of 2,500 afy, flow from adjacent sub-basins of 3,500 afy, and return flow from irrigation and municipal/industrial use of 365 afy.

Groundwater outflow estimates from the sub-basin include approximately 725 afy to domestic use (based on per person average), 2,400 afy to ET, 1,815 afy from groundwater discharging to surface water, and 4,000 afy flow out of the sub-basin, for a total of 8,940 afy.



Annual Groundwater Budget for the Tesuque Sub-Basin (1995)

Figure 27

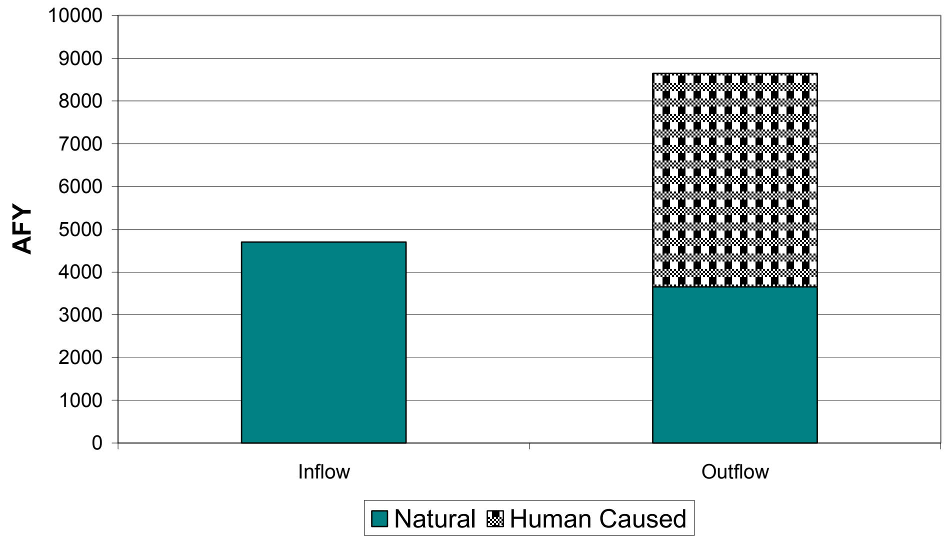
6.2.8 Summary of Water Budget Components for Caja del Rio Sub-Basin

All watercourses in the Caja del Rio Sub-Basin are ephemeral and currently ungaged. The surface inflow to the watershed (1,350 afy) was estimated using the elevation-area-yield approach. The estimate of the groundwater discharged to surface water is zero.

Total ET was estimated at 200 afy based on a riparian area of 92 acres. Comparison of all budget components resulted in an estimated stream loss to groundwater of 1,150 afy. Assessment of the sub-basin's surface water budget indicates that surface waters are in a natural state and only used in small amounts by livestock.

Assessment of sub-basin's groundwater budget indicates that groundwater is used primarily for municipal purposes by the City of Santa Fe; however, domestic and livestock wells divert approximately 85 afy. The Buckman wells, which supply the City of Santa Fe, pumped an average of 4,910 afy from 1990 to 1999, and have caused a water level decline of 500 feet over 30 years. As shown in Figure 28, this sub-basin has a net deficit of 3,945 afy, reflecting the difference between the amount of recharge and discharge from the sub-basin groundwater as evidenced by the large water level declines.

Groundwater supply is believed to be extensive, with an estimated storage of 20 million acre-feet. However, because surface waters are fully appropriated, stream-connected groundwater appropriations or transfers will be conditioned to require retirement of surface water rights to offset any depletions caused by groundwater pumping.



Annual Groundwater Budget for the Caja del Rio Sub-Basin (1995)

Figure 28

6.2.9 Summary of Water Budget Components for Santa Fe River Sub-Basin

The Santa Fe River and Arroyo Hondo constitute the primary surface water streams in the Santa Fe River Sub-Basin. Both are perennial in their upper reaches and lose most of their flow where their stream channels flow across deposits of the Santa Fe Group (Ancha and Tesuque Formations). The Santa Fe River is gaged in the upper reaches, where water is stored in the Nichols and McClure Reservoirs and diverted by the City of Santa Fe for municipal use and by four acéquias for irrigation use. Most years, seepage from the Nichols Reservoir maintains flow in the stream for several miles. Except in very wet years or after a storm event, the Santa Fe River is dry through town up to the point where either irrigation return flow from Acéquia Madre enters the river or effluent from the wastewater treatment facility discharges to the stream. Below this point flow diminishes until the river reaches La Cienega, where springs contribute to the flow. Where the river crosses La Bajada, most of the flow in the stream recharges the aquifer and reappears as springs, which discharge to the Rio Grande.

The amount of inflow from precipitation into the Santa Fe River is estimated at 7,850 afy, which includes estimated inflow from Arroyo Hondo. The Santa Fe River watercourse loses a significant amount of its flow to groundwater. The amount of seepage to the groundwater amounts to 3,770 afy on average above La Cienega and 4,730 afy below La Bajada. The Santa Fe River gains in the reach between La Cienega Springs and La Bajada at an average rate of 2,170 afy.

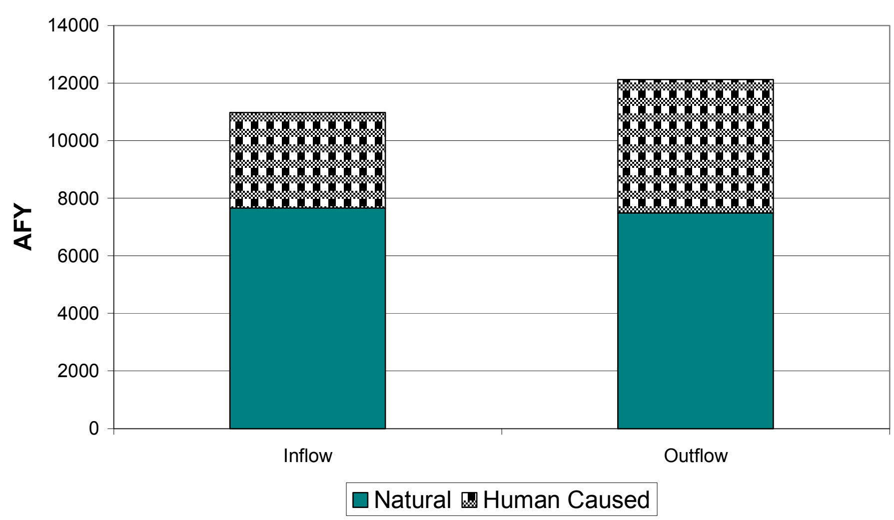
Estimated return flow in this sub-basin represents a combination of the average wastewater treatment plant discharge of 6,500 afy to the Santa Fe River (based on the discharges measured from 1993 to 1997), and an estimated irrigation return flow of 1,560 afy. Water is diverted from the Santa Fe River for both irrigation and municipal uses, the total of which is estimated at 7,290 afy. Of this amount, the irrigation diversion is computed at 2,665 afy and the estimated municipal diversion averages about 4,625 afy (based on diversions for the period 1990 to 1999).

The total amount of ET is estimated at 1,180 afy. This estimate is based on an estimated 80 acres of free water surface area subject to 45 inches per year evaporation, and 440 acres of riparian land subject to an ET rate of 24 inches per year. A surface water outflow of 1,110 afy is calculated as the residual from combining all other budget components. This outflow value is reasonable considering the large losses downstream of the gaging station (Santa Fe River above Cochiti Lake). The average flow was 8,450 afy measured at the gaging station during the years 1970-1997; seepage losses could be as high as 8,700 afy.

Recharge to groundwater occurs from the 3,770 afy of stream losses discussed above (1,600 afy is loss from natural streamflow, while 2,170 afy is from seepage or return flow from effluent). A total of 5,050 afy is estimated to recharge the groundwater at the mountain front. Another 1,000 afy recharges the groundwater as inflow from the North Galisteo Sub-Basin, and 1,150 afy recharges the groundwater from return flow from irrigation and domestic well use. The 1,150 afy return flow from groundwater diversions combined with the 2,170 afy from effluent that recharges the groundwater above La Cienega results in a total recharge from return flows of 3,320 afy. The estimated recharge to the aquifer below La Bajada (an area where few groundwater diversions occur) is 4,730 afy.

An average of 4,305 afy is diverted from the aquifer in the Santa Fe River Sub-Basin through City of Santa Fe wells and domestic wells. An average of 2,265 afy was calculated as the diversion from the City wells between 1990 and 1999, 765 afy for 1995 was reported as diverted from other metered (non-City) wells, and 1,275 afy is estimated as diverted from domestic wells based on the population not served by community systems. Evapotranspiration from shallow groundwater is estimated to be 1,200 afy and discharge through springs is estimated at 2,170 afy. The total flow out of the Santa Fe River Sub-Basin to other sub-basins and the Rio Grande is 4,120 afy. Of this amount, 1,050 afy moves toward the Caja de Rio Sub-Basin, 500 afy to the North Galisteo Sub-Basin and the remaining 2,570 afy enters the Rio Grande.

The total amount of recharge to the Santa Fe River Sub-Basin is almost 3,600 afy, substantially more than the amount discharged from the sub-basin. However, much of the recharge occurs downgradient of municipal and domestic wells. If the 4,730 afy that recharges the aquifer downstream of La Bajada is subtracted from the water budget, a net deficit of 1,130 afy can be calculated as the amount of water removed from storage in the areas where most of the groundwater is diverted, as shown in Figure 29. A greater deficit in the vicinity of the City wells can be estimated if the 2,170 afy of recharge occurring downstream of the wastewater treatment plant is considered. This larger deficit is supported by the long-term trends in water level declines observed in monitoring wells in the City of Santa Fe.



Annual Groundwater Budget for the Santa Fe River Sub-Basin (1995)

Figure 29

6.2.10 Summary of Water Budget Components for North Galisteo Sub-Basin

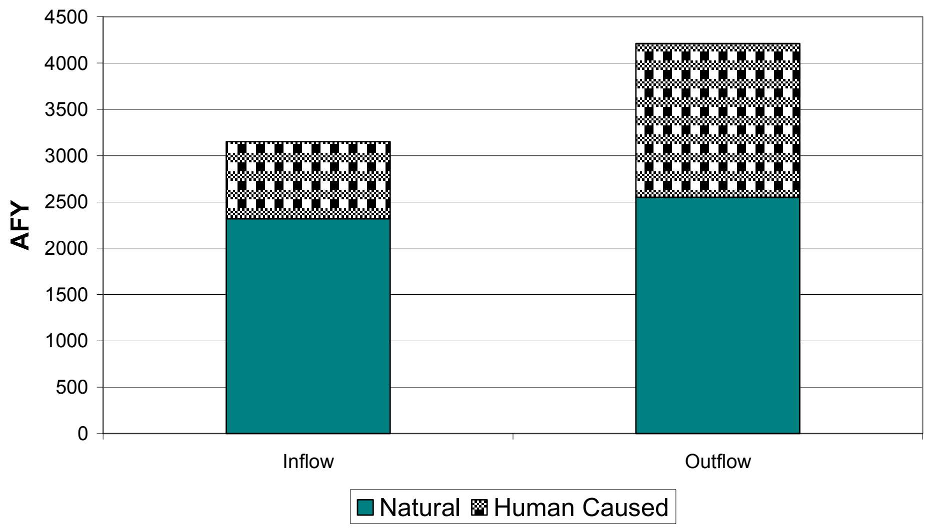
Surface water inflow in the North Galisteo Creek Sub-Basin was calculated at 900 afy. ET from an estimated riparian area of 65 acres near stream channels that are typically dry was estimated at 130 afy. The remaining budget balance of 770 afy was assumed to recharge the groundwater system through stream losses.

The North Galisteo Creek Sub-Basin receives little mountain-front recharge. A total of 1,550 afy of recharge occurs as inflow from adjacent sub-basins and another 830 afy recharges from return flow through septic tanks. These recharge amounts, combined with the estimated 770 afy of aquifer recharge from stream losses, bring the total recharge for this sub-basin to an estimated 3,150 afy.

Groundwater diversions for domestic, minor commercial, and school uses occur through municipal (535 afy) and domestic (1,125 afy) pumping for a total of 1,660 afy. Another 500 afy of groundwater outflow is estimated to occur through evaporation of shallow groundwater and 2,050 afy are estimated to move from the North Galisteo Sub-Basin to adjacent sub-basins. Thus, the total discharges from groundwater are equal to 4,210 afy, which is 1,060 afy more than the estimated recharge, as shown in Figure 30. Because little or no data exist to support the estimated budget values for the North Galisteo Creek Sub-Basin, these estimated components are considered very uncertain; however, it appears that significant groundwater mining may be occurring in this sub-basin. Figure 30 shows the balance between the inflows and outflows for the groundwater budget in the North Galisteo Sub-Basin.

6.2.11 Summary of Water Budget Components South Galisteo Sub-Basin

About 6,240 afy of surface-water inflow was calculated for the South Galisteo Sub-Basin. Irrigation diversions of 285 afy were estimated for 88 acres of land and irrigation return flow of 170 afy was computed. Groundwater discharge to surface water of 890 afy was estimated by balancing all other budget components. Water losses to ET were calculated at 2,570 afy, assuming (1) 1,050 acres of riparian vegetation experiencing an ET rate of 26 inches per year and (2) 125 acres of FWS area undergoing an evaporation rate of 45 inches per year. Surface outflow from the watershed, estimated at 4,440 afy, was based on the annual average measured flow at Galisteo Creek below Galisteo Reservoir during the period 1970 to 1997.

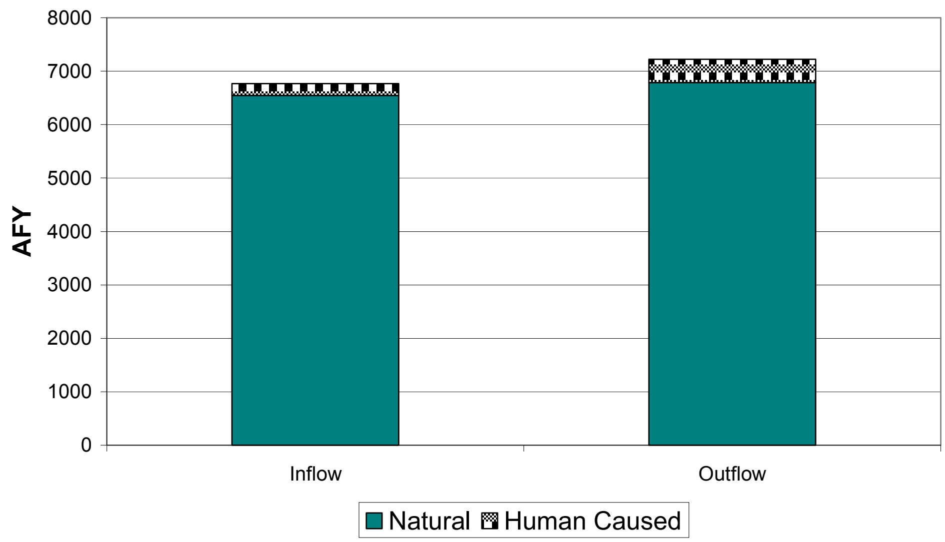


Annual Groundwater Budget for the North Galisteo Sub-Basin (1995)

Figure 30

Mountain-front recharge to the groundwater system in the South Galisteo Creek area is estimated to be 5,500 afy. Inflow from adjacent basins is estimated at 1,050 afy and recharge from domestic septic tanks is estimated at 215 afy. The total recharge rate to groundwater is estimated at 6,765 afy. Diversions from the groundwater system include 140 afy from metered wells, 295 afy from domestic wells, 1,300 afy from ET from shallow groundwater, and 890 afy of spring flow. A total of 4,600 afy of groundwater is discharged from the basin to the north and to the west (Rio Grande). Discharges exceed recharge by about 460 afy, indicating that groundwater mining may be occurring, as shown in Figure 31.

A relatively small amount of surface water is used for irrigation and groundwater is diverted for domestic use. Historically, water was used for the heap leaching operation and dewatering the gold mine in the Ortiz Mountains. This operation has ceased, although efforts have been made within the past decade to resume mining.



Annual Groundwater Budget for the South Galisteo Sub-Basin (1995)

Figure 31

6.3 Projected Water Uses for 60-Year Planning Horizon

Water planning is typically performed for a 40-year horizon; however, the JySWPC chose to extend some projections through 2060 for this planning region. To ensure that sufficient water will be available to meet future needs in the planning region, both the population of the region and the water uses (demands) were projected, as described below.

6.3.1 Projected Demographics

The BBER at the University of New Mexico (UNM) was retained to provide population projections for the Jemez y Sangre Water Planning Region (Table 23). The results of the in-depth analysis of the ten sub-basins are available in the *Population Projections for the Jemez y Sangre Water Planning Region* (BBER, 2000) (Appendix E). This study includes:

- A historical section, which summarizes the population estimates from 1970 to 1999 for each of the ten sub-basins, including an explanation of the geography and other demographic characteristics.

Table 23. Historical and Most Likely Population Projection
Jemez y Sangre Water Planning Region

Sub-Basin	Population									
	1970	1980	1990	2000	2010	2020	2030	2040	2050	2060
Velarde	2,459	3,447	3,671	4,974	5,637	6,313	6,861	7,311	7,729	8,130
Santa Cruz	10,487	12,974	18,094	20,768	23,713	27,435	31,104	34,788	38,847	43,383
Santa Clara	2,655	3,858	3,956	3,870	4,380	4,900	5,320	5,664	5,981	6,286
Los Alamos	15,646	18,218	18,609	19,497	20,509	21,422	22,105	22,573	22,682	23,137
Pojoaque-Nambe	1,731	3,405	4,794	6,280	7,559	9,580	11,988	14,799	18,229	22,383
Tesuque	1,048	1,375	3,268	4,859	6,898	9,306	13,818	17,263	23,026	30,422
Caja del Rio	101	101	262	554	693	912	1,185	1,518	1,942	2,476
Santa Fe	45,057	59,412	71,961	87,709	104,092	118,824	132,404	143,467	152,250	157,092
North Galisteo	898	2,324	5,834	11,072	13,837	18,208	23,658	30,326	38,785	49,449
South Galisteo	685	1,447	1,665	2,903	3,608	4,970	6,714	8,896	11,700	5,273
Total	81,682	106,561	132,114	162,486	177,089	221,870	255,157	286,605	314,571	358,031

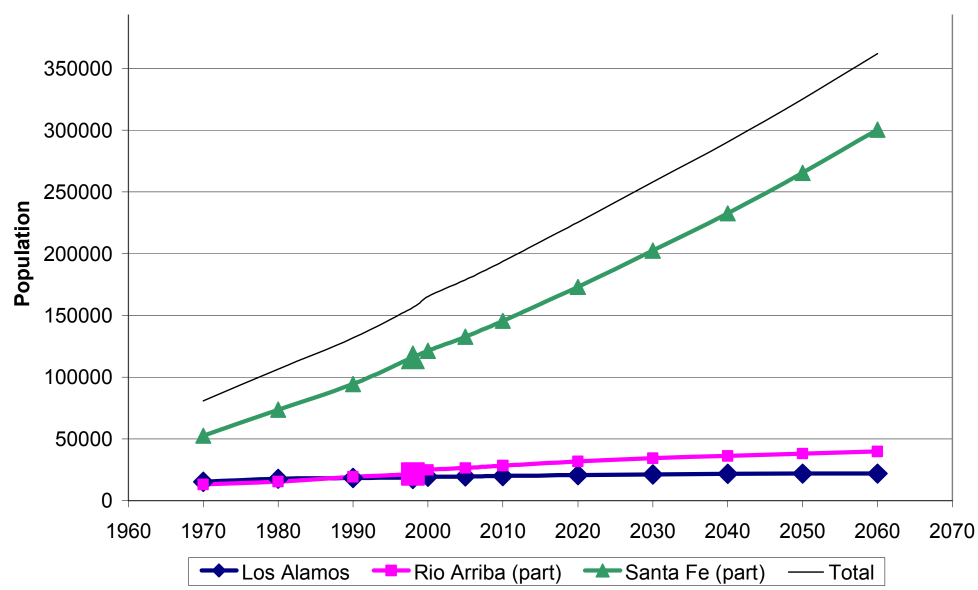
Source: BBER, 2000, 2002.

- Population projections for the sub-basins from 2000 to 2060 under three growth scenarios: low-growth, most-likely, and a mathematical extrapolation to project historical population growth to 2060.

- Potential impacts to population projections from hypothetical large economic changes.

- Examination of water availability and the impacts of a “preservation scenario” in which water from agriculture is not moved to municipal or domestic use.

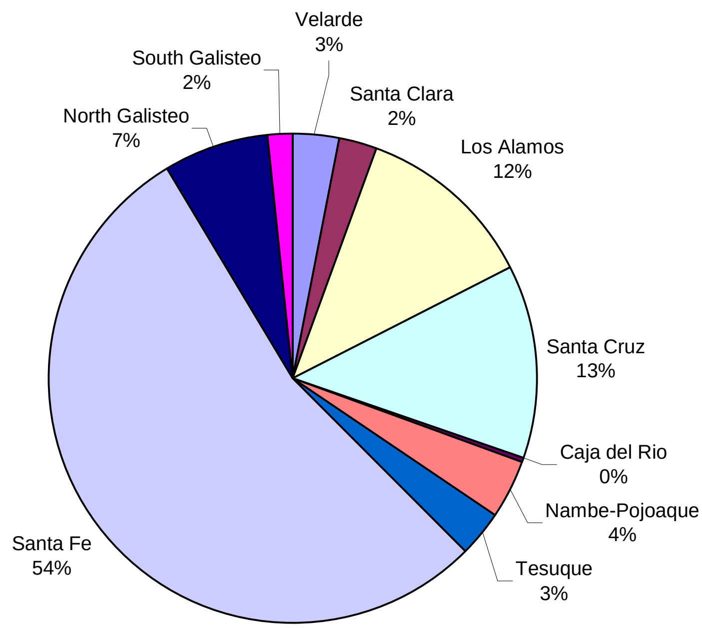
The most-likely population projection served as the basis for projected future water demand. The projections provided in the BBER 2000 report were updated in 2002 for Rio Arriba and Los Alamos Counties to reflect the revised estimates of the population based on the 2000 Census, results of which were not available at the time of the BBER report. Therefore, the values listed in Table 23 for the sub-basin populations and projections differ from the BBER 2000 report. Figure 32 illustrates the projected population in the planning region, by county.



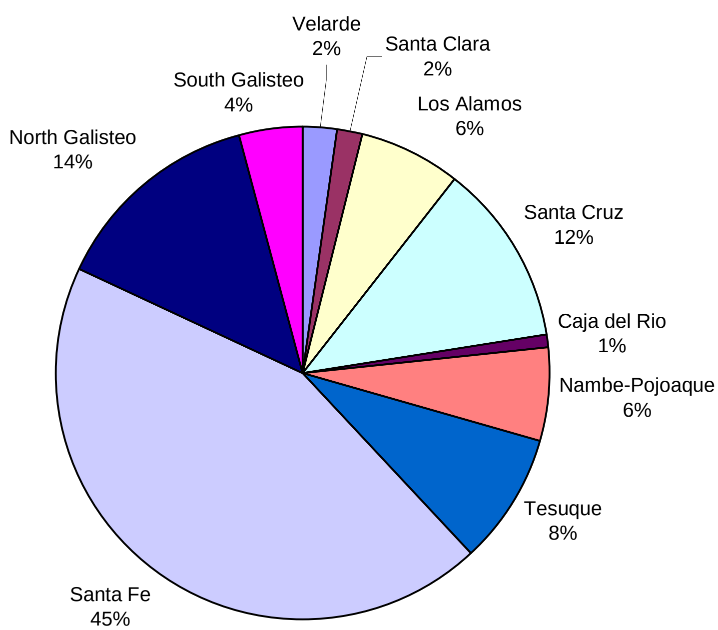
"Most Likely" Population Projection for Parts of Counties within the Jemez y Sangre Water Planning Region

Figure 32

Figure 33 shows population by sub-basin for 2000 and 2060.



Year 2000



Year 2060

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JEMEZ Y SANGRE REGIONAL WATER PLAN

Population by Sub-Basin for 2000 and 2060

Figure 33

The most-likely projection (as well as the other projections provided in the BBER report) is not constrained by water availability. The projection assumes that water will be available for the projected population. This is not meant to suggest that there will necessarily be enough water, but rather to avoid prejudging the conclusions of the full supply/demand study.

A summary of the population projections, prepared by Lindsey Grant on behalf of the JySWPC Population Subcommittee, is provided in Appendix E.

As shown in Figure 32, the population of the sub-basins within the three-county area is projected to increase from a total of about 160,000 to 360,000 people from 2000 to 2060, provided that the trends of improved life expectancy and declining fertility continue. The projection also assumes that net in-migration levels will be similar to the trends observed from 1985 to 1998. The projected net in-migration for Los Alamos and Rio Arriba Counties is negative, whereas the projection for Santa Fe shows a positive net in-migration, accounting for 40 to 60 percent of growth in the sub-basins within Santa Fe County. The Santa Fe River Sub-Basin accounts for more than half of the population in the region in the year 2000 (Figure 33), but this predominance is projected to be reduced by 2060 (Figure 33). The population projections for each sub-basin are shown in Appendix E, along with the annual growth rate.

The Jemez y Sangre Water Planning Region experienced significant growth from 1970 to 1999, nearly doubling its population. Overall, the region will experience slower population growth in the next 40 to 60 years, due mainly to increasing median age and declining fertility rate. Santa Fe County will continue to draw both young and elderly migrants for reasons such as tourism, environmental and cultural amenities, and employment expansion in the areas of government, service, and high-tech industries. Projected annual growth rates across the planning region for the period from 2010 to 2015 vary from 0.93 percent in the Velarde Sub-Basin to as much as 2.76 and 3.49 percent in the North Galisteo and Tesuque Sub-Basins, respectively.

Population projections are highly uncertain and many factors could influence the rate of growth, including a water supply shortage. Migration patterns could be impacted by changes in the U.S. economy or by immigration laws. Changes in fertility rates could impact the projections, as could changes in the local economy. BBER projected the impact of a dramatic change, such as a large company locating in Santa Fe or the closing LANL. Under the scenario where a company with 5,000 employees moves to Santa Fe, the increase in employment after 60 years would be about 4 percent more than the baseline projections; conversely, the closing of LANL could result in a reduction of the employment projections by 33 percent.

Land availability was not considered in the population projections because density of the urban area can increase to accommodate potential growth.

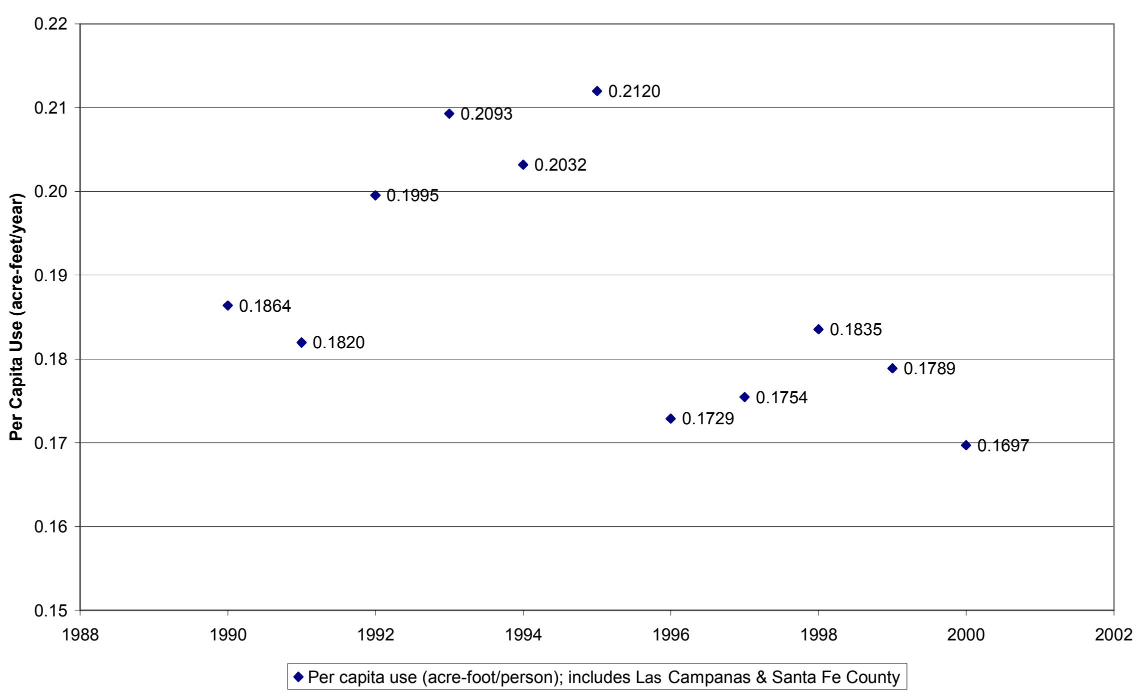
6.3.2 Projected Water Demands by Category of Use

In the BBER study (2002), projected demands focus on municipal, industrial, commercial, and domestic use only. The regional trend in agriculture in the region is downward, as far as the amount of acreage irrigated. Therefore, an increase the number of acres in agriculture was not projected and the amount of water used by irrigation was assumed to remain constant.

Future water demand was based on the projected population multiplied by 0.15 acre-foot per person for each sub-basin (except in the Santa Fe River Sub-Basin). The 0.15 acre-foot per person includes all non-agricultural uses of water in each sub-basin. Domestic wells in sub-basins without municipal systems are likely to serve businesses such as gas stations, restaurants, etc., in addition to domestic usage. For the Santa Fe River Sub-Basin, the current per capita rate of water use for persons connected to the City water system is 0.183 acre-feet per person. The population not connected to the City water system, but within the sub-basin, was assumed to divert 0.096 acre-feet per person. This rate reflects the City's conservation ordinance, but is representative of a period when no drought restrictions are in place. Additional information on projected demands is provided in Section 6.5.

6.4 Water Conservation

Water conservation is a responsible, efficient method to address growing water demands. The City of Santa Fe, which serves about 70,000 people (more than half of the population in the Jemez y Sangre Water Planning Region), developed a comprehensive demand management program after acquiring the water company in 1995. An emergency demand reduction ordinance and a comprehensive water conservation ordinance, adopted by the City in 1996, have served to dramatically reduce the city's per capita rate of water consumption (see Section 6.5). One of the most significant elements of the conservation ordinance was the establishment of an aggressive water conservation rate structure that rewards low water users and penalizes high water users. Users are fined for watering between the hours of 10 am and 4 pm and for fugitive water. As a result of these measures, a 24 percent per capita reduction in water use was realized between 1995 and 2000. Overall, the rate of use decreased from a high of 0.21 acre-foot per person in 1995 to 0.183 acre-foot per person in a normal supply year. In 1996 and 2000, the supply was very low and outdoor water use was restricted to once a week for part of the year. In wet years, the water use is lower due to the reduced amount of irrigation. Figure 34 shows the annual per capita water use in the City of Santa Fe from 1990 to 2000.



City of Santa Fe Water Use
Figure 34

Water demand at LANL is projected to increase as a result of new mission requirements. If LANL significantly increases operation of present facilities or constructs additional ones, its historical water usage could be exceeded. Consequently, LANL has established a number of conservation and greywater reuse programs designed to reduce water consumption and increase the efficiency of use. For example, the Cooling Tower Water Conservation Project should reduce the total amount of water used in cooling towers even with the start-up of the new Strategic Computing Complex in 2002.

6.5 Drought Management

Droughts affect the amount of surface water, the amount of recharge, and the demands for water in the region. Droughts vary in frequency and severity and can greatly impact the management of water in the region. From a legal perspective, priority calls are the overriding rule that governs the distribution of water during times of shortage. In reality, however, priority calls are rarely used. Instead, local and regional entities in areas vulnerable to drought have developed methods for addressing the shortages.

A number of drought management plans have been developed in the Jemez y Sangre region, some of which are described below. In some communities, the only option available during droughts that severely impact surface supply is to provide water through a National Guard water truck. This was the case in Cerrillos during 2002. Communities that are considering an increased dependence on surface water must develop a drought contingency plan. Procedures for developing these plans are outlined in Section 8, Recommendation 20 and in White Paper 20, *Gaining Water Use Efficiency (Reducing Water Use Demand) in the Jemez y Sangre Region* (Appendix F).

6.5.1 City of Santa Fe Drought Ordinance

Beginning in May 1996, the City of Santa Fe adopted a Water Conservation Ordinance and Water Emergency Management Plans that specify a series of stages of water emergency. The purpose of the ordinance/plans, which have been amended several times, is to enable the City to implement measures for controlling water use in response to water-system-related emergencies or catastrophic events that may disrupt system operations. A water service emergency can be based on one or more of the following conditions:

- A general water supply shortage due to increased demand or limited supply

- City water distribution or storage facilities are inadequate to meet demand or minimum quality standards

- A disruption of the supply, storage, and distribution facilities of the City water utility occurs

The ordinance declares four stages of drought emergency in addition to measures that are to be taken at all times. A summary of the measures outlined in the ordinance is provided below.

All Times
At no time shall water be wasted or used unreasonably. Unreasonable uses of water include but are not limited to the following practices:

- A customer must not let water leave the customer's property by drainage onto adjacent properties or public or private roadways or streets due to excessive irrigation and/or uncorrected leaks.

- A customer will not fail to repair a water leak upon initial notification.

- A customer will not use water to wash down sidewalks, driveways, parking areas, tennis courts, patios or other paved areas, except to alleviate immediate safety or sanitation hazards.

- No landscape watering is permitted between 10 am and 6 pm (May 1 through October 31).

- Restaurants and banquets may serve water only upon request.

Stage 1. Voluntary Compliance—Water Watch

Stage 1 applies when the possibility exists that the City of Santa Fe water utility will not be able to meet up to 15 percent of the annual demand projection of its customers. When Stage 1 conditions exist, all Stage 2 and 3 measures apply on a voluntary basis.

Stage 2. Mandatory Compliance—Water Alert

Stage 2 applies when the probability exists that the City of Santa Fe water utility will not be able to meet from 16 to 35 percent of the water demands of its customers. The following measures are to be taken during Stage 2 and higher stages:

- The planting of all new turf seed and sod is prohibited. The planting of all other new in-ground landscaping and outdoor containerized landscaping is strongly discouraged.

- The odd-even-address, three-day-per-week watering schedule shall apply.

- One initial filling of a swimming pool is allowed for recirculating pools. Non-recirculating pools may not be filled or refilled.

- Non-recirculating fountains are prohibited.

- Vehicle washing at residences is prohibited. All vehicle washing is limited to once-per-month at commercial car wash facilities, including do-it–yourself facilities.

- Posting of water shortage bulletins is required in all restrooms, shower, and locker facilities at all non-residential facilities.

- All commercial entities must have the following installed within two weeks of the effective dates of the Stage 2 declaration: (1) shower heads with a flow rate not to exceed 2.5 gpm and (2) lavatory and kitchen faucets equipped with aerators so that flow does not exceed 2.5 gpm.

- Drought emergency surcharges shall be applied to water bills for all customers served by the City water utility as follows:

  – Residential customers: $15.00 per 1,000 gallons for all usage above 10,000 gallons per month (up to 20,000 gallons month); $25 per 1,000 gallons for all usage above 20,000 gallons per month.

  – Small and large commercial customers: $2.00 per 1,000 gallons on all usage.

Stage 3. Mandatory Compliance—Water Warning

Stage 3 applies when the City of Santa Fe water utility will not be able to meet from 36 to 50 percent of the water demands of its customers. In addition to the restrictions for Stages 1 and 2, the following measures apply during Stage 3 conditions:

- Irrigation is limited to one day per week.

- Plant nurseries and landscape professionals or community gardens must provide their customers with city-provided information about the one-day-per-week water restrictions at the time of sale of service contract. Greywater and water harvested from precipitation shall be exempt from the one-day-per-week watering restriction.

- Swimming pools without covers are prohibited. All pools must be covered when not in use. The filling and refilling of swimming pools or spas at single family residences is prohibited.

- The use of all ornamental fountains is prohibited.

- Lodging facilities will not change the sheets and towels more than once every four days for guests staying more than one night, unless there is a justified public health reason.

- If an effluent fill station is permitted by the State and effluent is available, the use of potable water for construction purposes through a metered hydrant is prohibited.

- User fees detailed for Stage 2 apply under Stage 3.

Stage 4. Mandatory Compliance—Water Emergency

Stage 4 applies when a major failure of any supply or distribution facility, whether temporary or permanent, occurs in the water distribution system, leading to a probable shortage in excess of 50 percent of anticipated demand. Under the Stage 4 implementation plan:

- All outdoor irrigation of turf and ground cover is prohibited with the exception of plant materials classified to be rare, exceptionally valuable, or essential to the well-being of the public at large or rare animals. Irrigation of trees and shrubs is permitted only by hand-held hose equipped with a positive shot-off nozzle, hand-held container, or drip irrigation system.

- The use of water at commercial nurseries, commercial sod farms, and similarly situated establishments must be reduced in volume by an amount determined through the Stage 4 implementation plan.

- The washing of automobiles, trucks, trailers, boats, airplanes and other types of mobile equipment is prohibited.

- The filling, refilling or adding of water to swimming pools, spas, ponds, and artificial lakes is prohibited except where this use is storage for a water supply.

- The watering of all golf course areas is prohibited.

- Use of water from fire hydrants must be limited to fire fighting or other activities immediately necessary to maintain the health, safety, and welfare of the citizens served by the municipal system.

- The use of water for commercial manufacturing or processing purposes must be reduced in volume by an amount determined through approval of Stage 4 implementation plans by the governing body.

- All sales of non-reclaimed water outside of the water service area will be discontinued, with the exception of sales previously approved by the governing body.

- No new construction meters will be issued.

- Except for property for which a building permit has been issued, no new building permits will be issued, except under one or more of the following circumstances:

  – For projects necessary to protect the public's health, safety, and welfare

  – When using reclaimed water

  – When the recipient of the building permit can demonstrate that no net increase in water use will occur

  – Where the recipient of the building permit provides a conservation offset

6.5.2 Eldorado Area Water and Sanitation District Water Alert Management Plan

The purpose of the Eldorado Water Alert Management Plan is to establish a graduated set of actions by which the Eldorado Area Water and Sanitation District, water users, and El Dorado Utilities (EDU) may respond to water shortage conditions. This plan was developed in 1999 in response the limited ability of the supply to respond to increase demands that result during dry periods. Since the beginning of 2003, pending management changes make it likely that the plan may be modified. The following water alert stages and their restrictions are defined as part of the Eldorado Area Water and Sanitation District Water Alert Management Plan:

Normal Stage

This stage exists at all times when other stages are not in effect. The following normal conservation measures apply:

- Water only three days a week.

- Water only after 6 p.m.
- Check water system for leaks.
- Wrap hot water pipes and water heaters with insulating material to reduce the time it takes for hot water to reach the tap.
- Be sure water heater thermostat is not set too high.
- Check water requirements for various makes and models when considering purchasing any new appliances, as some use less water than others.
- Use moisture meter to determine when houseplant need water.
- Flush toilets only when necessary and do not use toilets as trash receptacles.
- Reduce water level per flush by installing a water displacement device in toilet.
- When building or remodeling bathrooms, use low volume flush toilets.
- Install aerators on sink faucets.
- Install water-saving shower heads.
- Take showers instead of baths; take shorter showers.
- Do not let water run while brushing teeth or other activities.
- Collect water from tap while waiting for hot water and use for plants and pets.
- Sweep with a broom instead of a hose to clean paved surfaces.
- Use a pail of water when washing cars.
- Learn principles of xeriscape.
- Use drip irrigation systems and adjust according to weather conditions.
- Use mulch and other techniques for treating the soil to reduce run-off and reduce the watering needs of the landscaping.

Water Alert Stage 1

This stage exists when there is a strong expectation that there will soon be insufficient precipitation to meet outdoor water usage and/or that EDU occasionally may not be able to produce water at the same rate it is being consumed. Additional conservation measures are placed in effect, including the following:

- Post *Water Alert Stage 1* signs at subdivision entrances and at Eldorado Community Center.

- Adhere to odd/even watering that restricts watering to three days per week.
- Postpone new outdoor planting until Stage 1 is lifted.
- Turn off all decorative water devices.
- Do not add water from your home to swimming pools, spas, ponds, etc.
- Reduce watering of recreation fields.

Water Alert Stage 2

This stage exists when, for an extended, period EDU cannot produce water at a rate to meet consumption or when water storage declines to dangerous levels and EDU cannot restore them to safe levels. Dangerous levels are determined when water storage falls to 60 percent of capacity. Stage 2 is lifted when storage reaches 90 percent of capacity and stays above 75 percent for 30 days or the end of that billing cycle, whichever is greater. The most severe conservation measures and special temporary conservation water-usage rates are placed in effect by EDU at the time. The following additional conditions apply:

- Post *Water Alert Stage 2* signs at all subdivision entrances and at Eldorado Community Center.

- Catch rainwater and save bath, shower and washing machine water to watering outside plants.

- Do not wash vehicles.

- Suspend use of recreation fields where watering is required.

- Implement the following surcharges: $5.00 per 1,000 gallons over 6,000 gallons; $15 per 1,000 gallons over 20,000 gallons.

6.5.3 Santa Cruz Irrigation District Water Management

Acéquias and private ditches served by the Santa Cruz Irrigation District (SCID) were first used for irrigation in 1695, although SCID was not formed until 1925. Santa Cruz Reservoir was built in 1929, which improved the ability of SCID to manage the water supply. Although the water rights within SCID have priority dates, users have traditionally shared water during shortage years. Each year, based on the availability of runoff, the SCID determines how the water will be shared. If the reservoir is full and the snow pack is plentiful at lower elevations, all acéquias and private ditches receive their full supply. If both the water supply in the reservoir and snowpack are low, deliveries of water will be reduced to three days per week or less, depending on the rate at which the reservoir refills after a release has been made.

Within the SCID, a *mayordomo* serves as a policeman to regulate the deliveries of water. The senior water rights holders theoretically receive water the first two days during a shortage, while the junior water rights holders receive the next two days of water. However, because the senior water rights holders are typically located on the lower acéquias, this system does not always work. Often the mayordomo must regulate the deliveries from top to bottom, allowing each field the allotted amount of water.

6.5.4 Pojoaque Valley Irrigation District

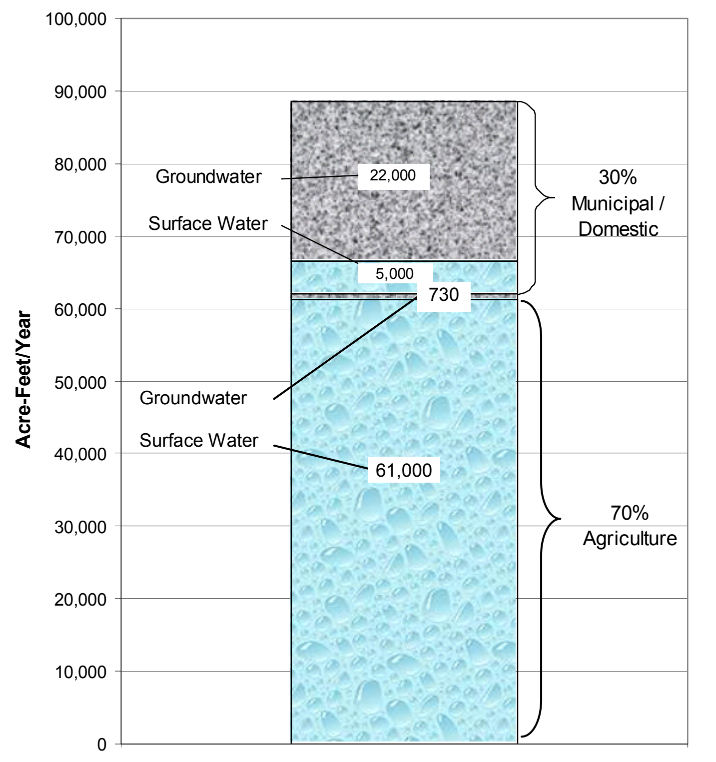
The acéquias and private ditches within the PVID began irrigating centuries ago, even though PVID was not established until 1974. Nambe Reservoir, built in 1976, provided PVID and the Pueblos flexibility to manage their water supply, part of which involves an exchange of SJC water to offset depletions from the project. The Bureau of Reclamation works with the Pueblos and PVID to develop a schedule of releases each year based on the availability of water. The drought plan recognizes the Pueblos' right to use all natural flows in times of shortage.

The Pueblos allow storage of natural flows over 10 cfs during the irrigation season. When there is a water shortage, a rotation system is used that is based on the division of the system into upper and lower sections. The Bureau of Reclamation assists in the development of the rotation and develops the calculations and release schedule; the schedule is reviewed, coordinated, and approved by the Pueblos and PVID before implementation. The rotation starts from the lower section of the system, with San Ildefonso and Pojoaque Pueblos receiving the natural flows "riding" on the storage releases for the lower ditches. Nambe Pueblo gets the natural flows when the upper ditches get their storage waters. The number of days in the rotation varies depending on the availability of water in storage at the beginning of the irrigation season and how much water the PVID has in storage at the time of releasing stored irrigation water.

6.6 Summary of Present and Future Water Demand

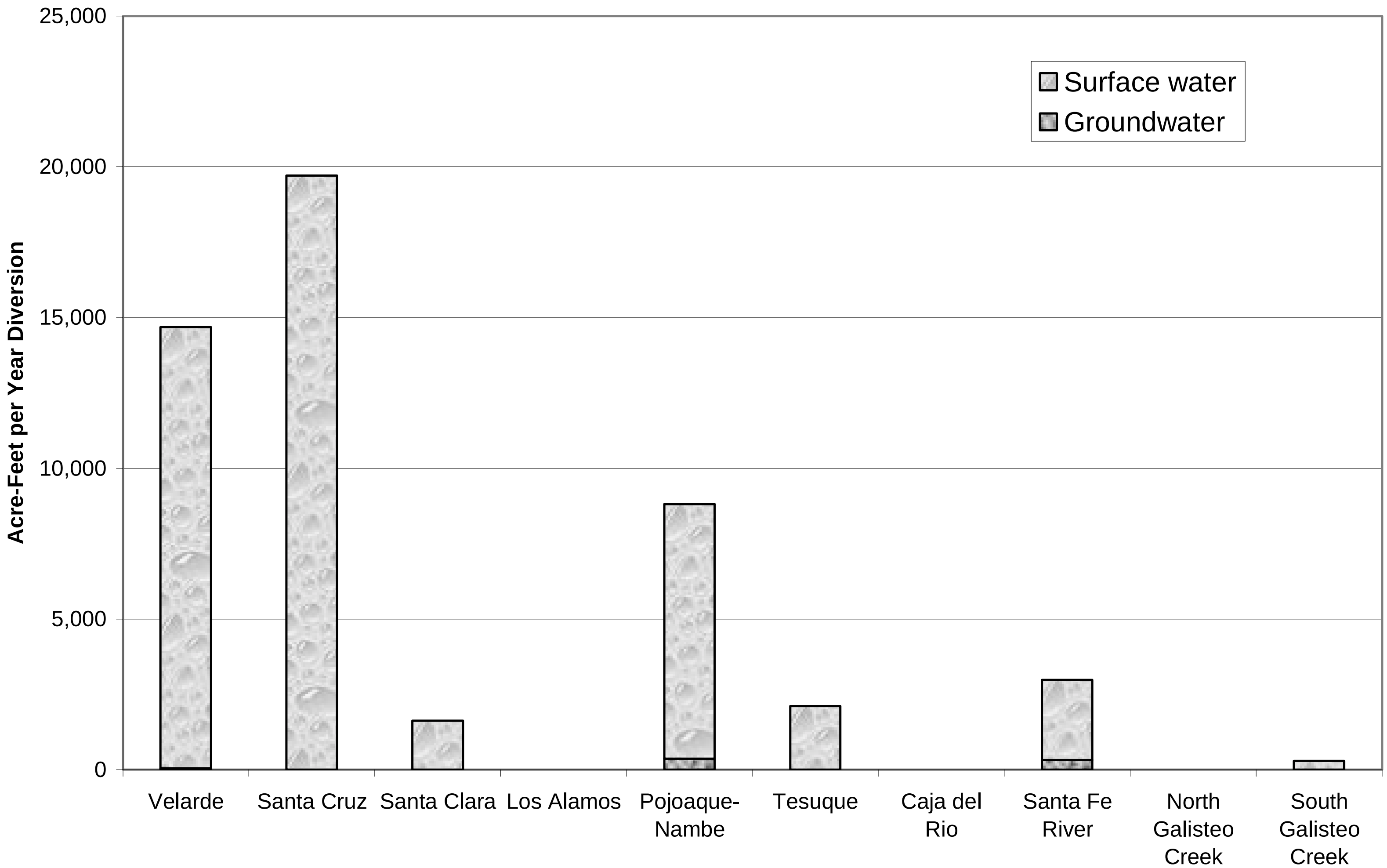
In the Jemez y Sangre Water Planning Region, 70 percent of the water is used for agriculture and 30 percent is used for municipal, domestic, and industrial purposes. Figure 35 shows the estimated current annual water demand by all users in the region. Surface water provides most of the supply (61,000 afy) for irrigation diversions, with a small amount of irrigation supply coming (730 afy) from groundwater. Groundwater provides 22,000 afy of the municipal, domestic, and industrial uses, while 5,000 afy are diverted from surface water (Santa Fe River for the City of Santa Fe).

Figure 36 shows irrigation diversions. Most irrigation occurs in the Velarde, Santa Cruz, and Pojoaque-Nambe Sub-Basins, with small amounts in Santa Clara, Tesuque, Santa Fe River, and the South Galisteo Sub-Basins. The distribution of municipal, domestic, and industrial uses is shown, by sub-basin, in Figure 37.



Estimated Current Annual Water Demand by all Users
Figure 35

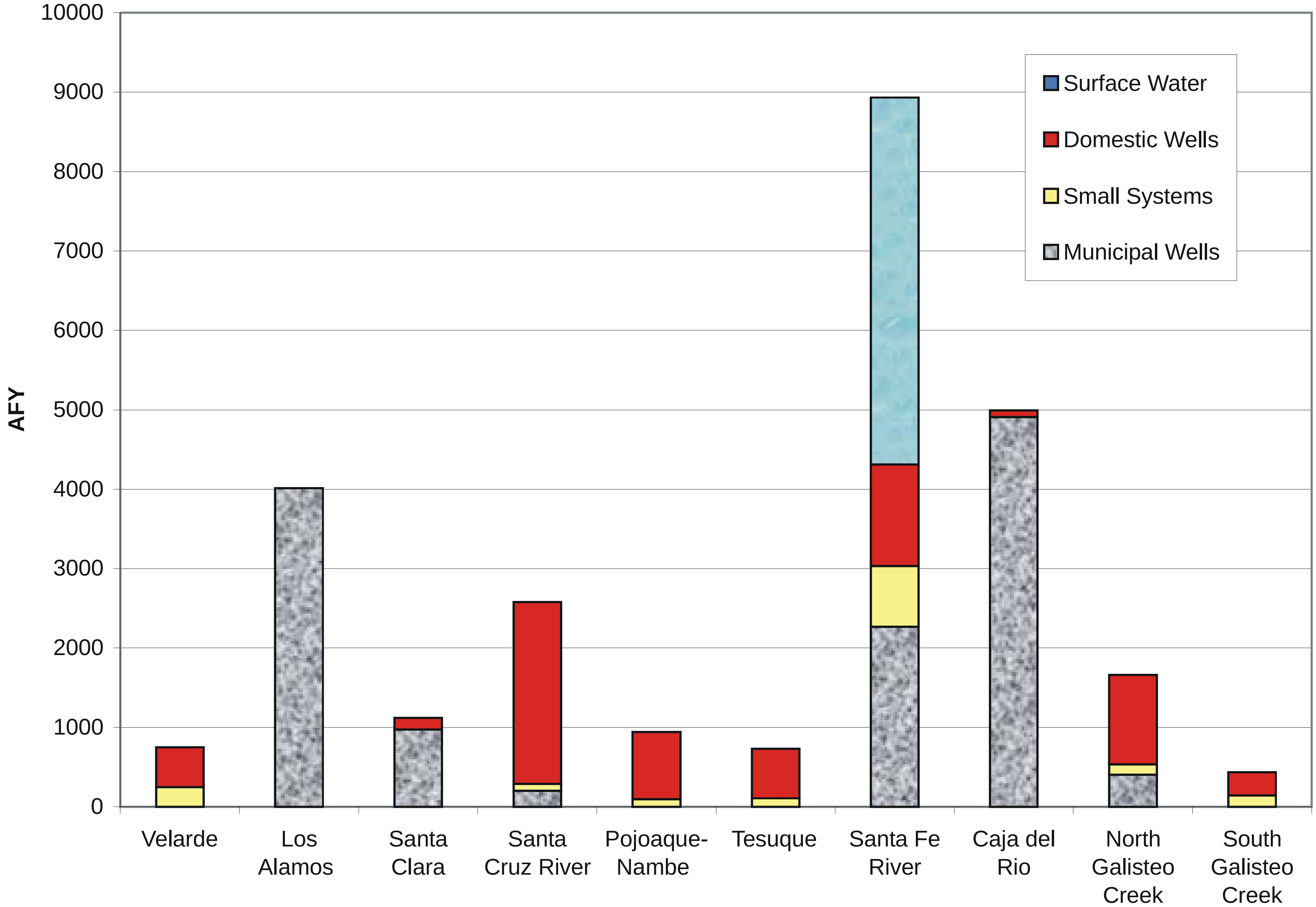
Figure 38 shows the projected water demand for the entire region and the source of supply for existing demand. The projected demand by 2060 is 31,500 afy more than the current demand. Distribution by sub-basin of this demand is shown in Figure 39. Based on projected growth,



JEMEZ Y SANGRE REGIONAL WATER PLAN

Irrigation Diversions (1995)

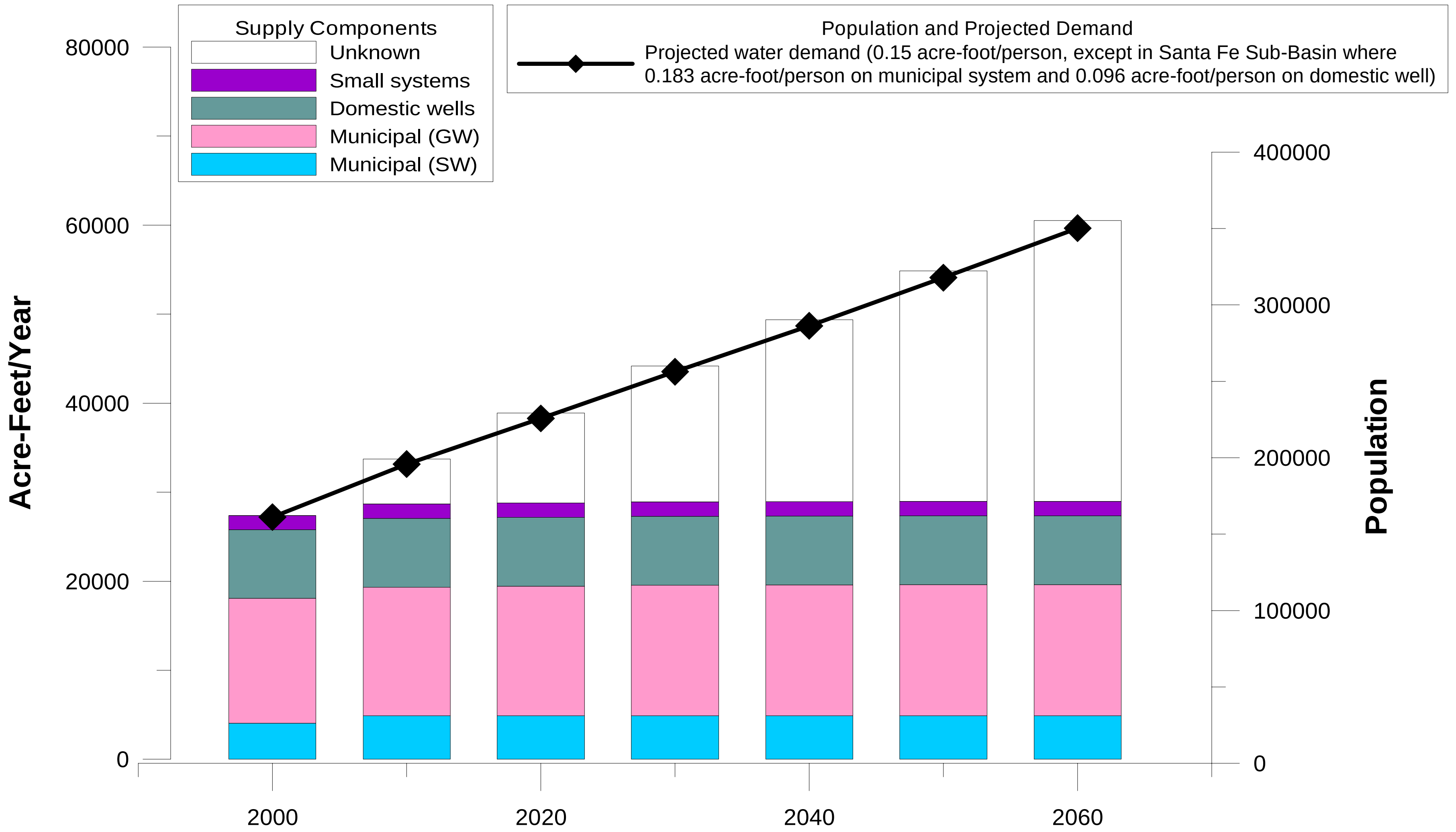
Figure 36



JEMEZ Y SANGRE REGIONAL WATER PLAN

Annual Estimated Municipal/Domestic Diversions, 1995-2000

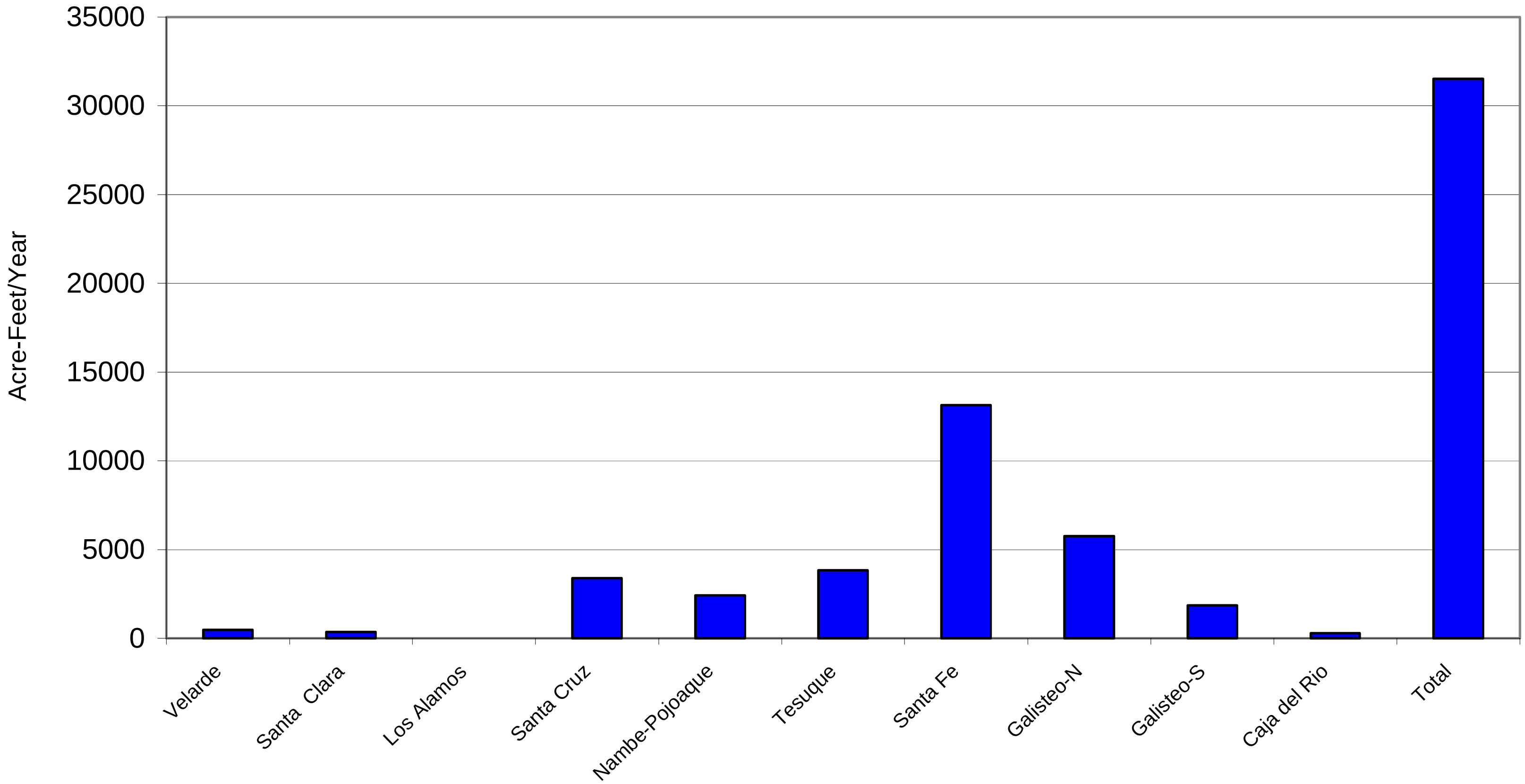
Figure 37



JEMEZ Y SANGRE REGIONAL WATER PLAN

Projected Domestic and Municipal Water Demand in the Region

Figure 38



JEMEZ Y SANGRE REGIONAL WATER PLAN

Projected Domestic and Municipal Water Deficit in 2060 by Sub-Basin

Figure 39

demand is most concentrated in the Santa Fe River, North Galisteo, Tesuque, Santa Cruz, and Pojoaque-Nambe Sub-Basins.

The projected water demand and current supply for each of the sub-basins are shown in Figures 40 through 49 and in Table 24.

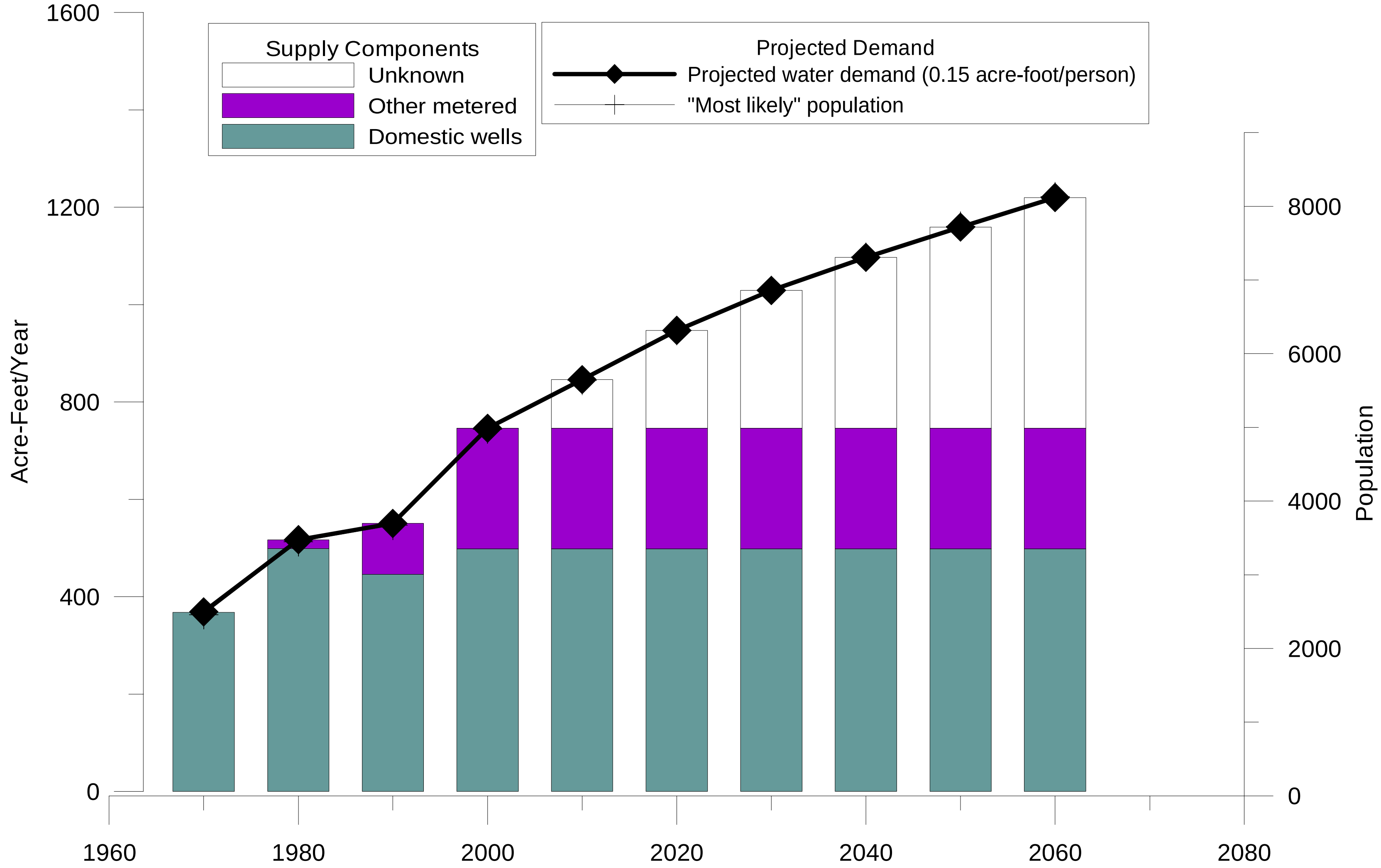
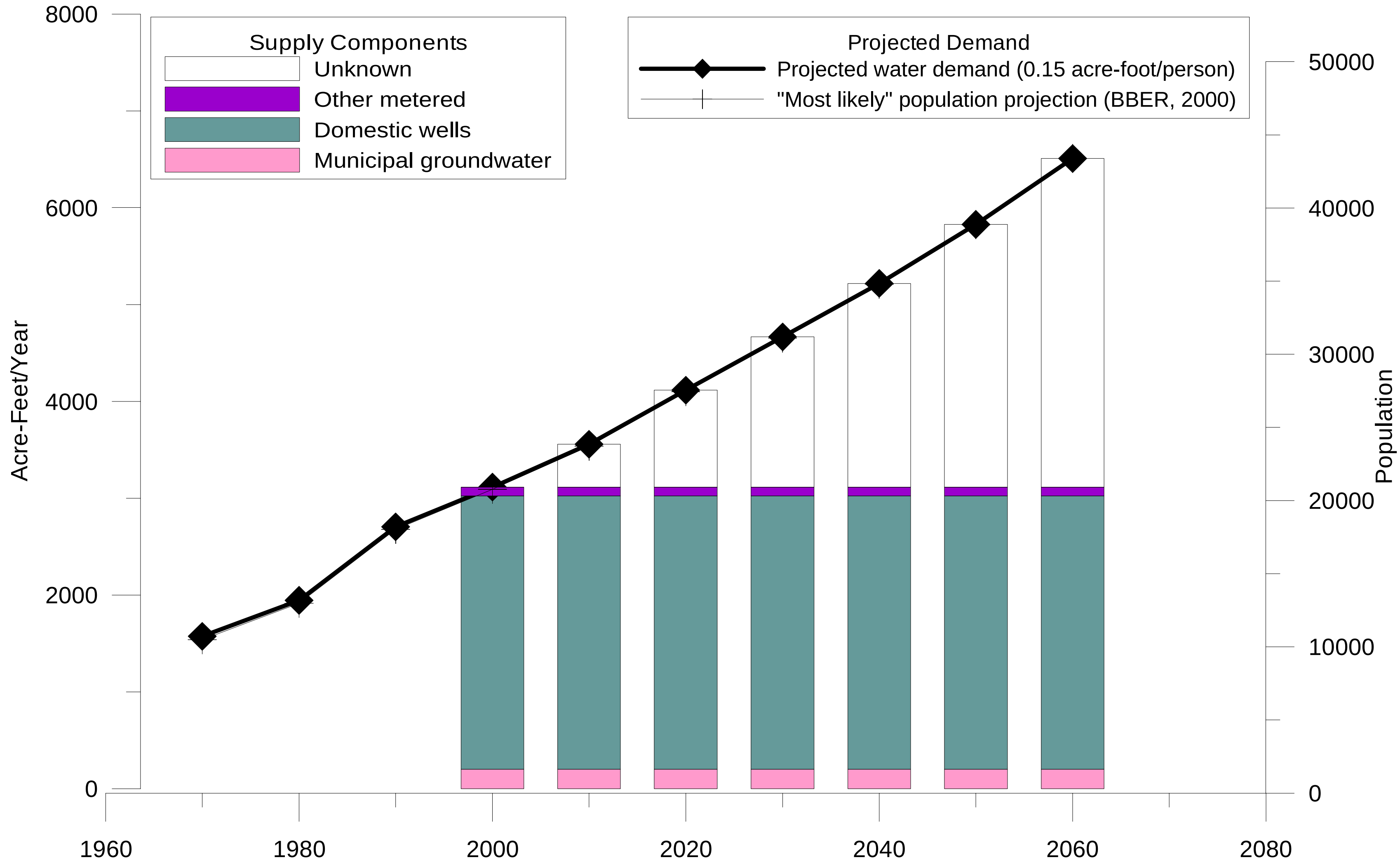


Figure 40

JEMEZ Y SANGRE REGIONAL WATER PLAN

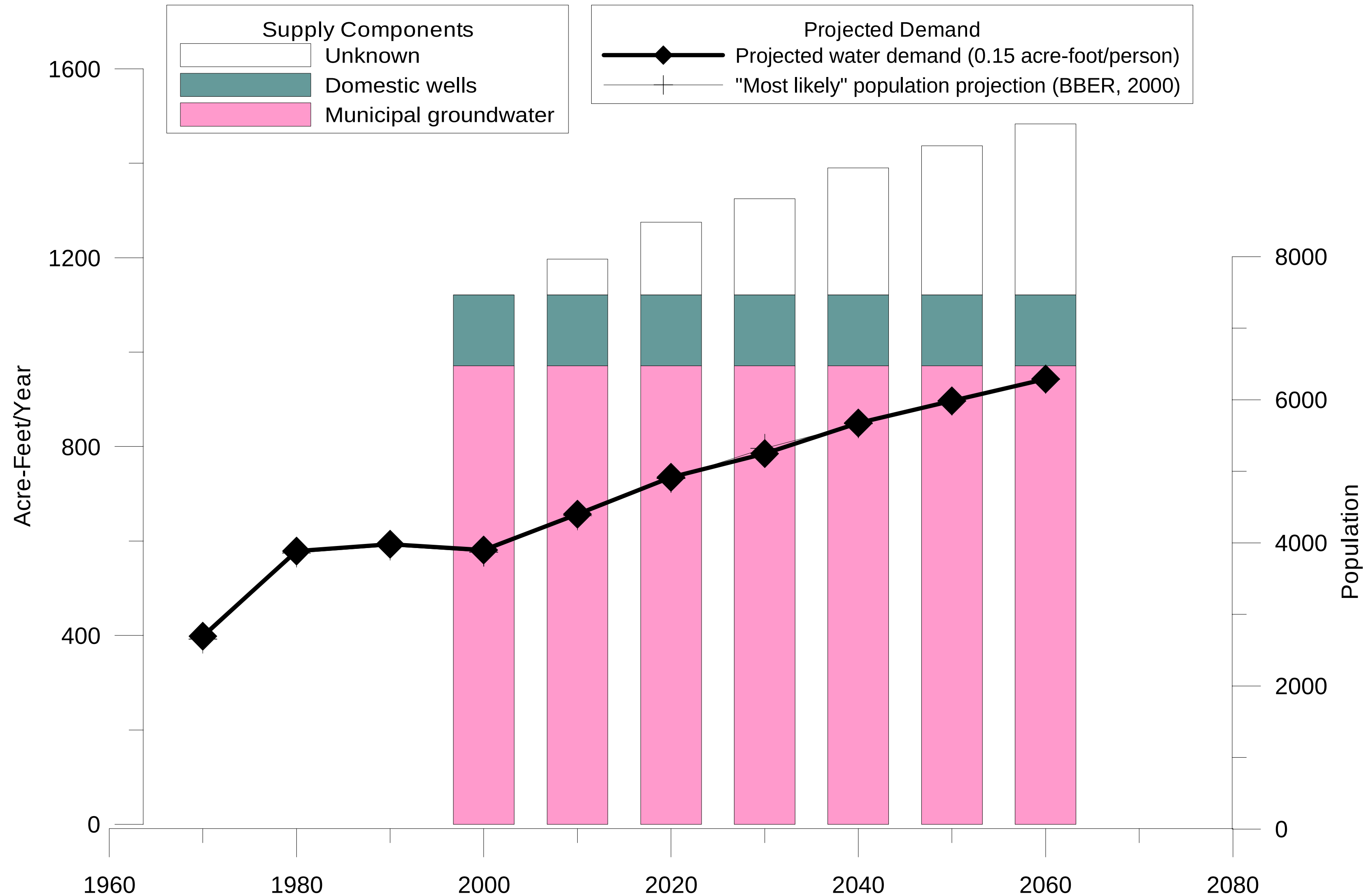
Domestic Water Demand in the Velarde Sub-Basin



JEMEZ Y SANGRE REGIONAL WATER PLAN

Domestic and Municipal Water Demand in the Santa Cruz Sub-Basin

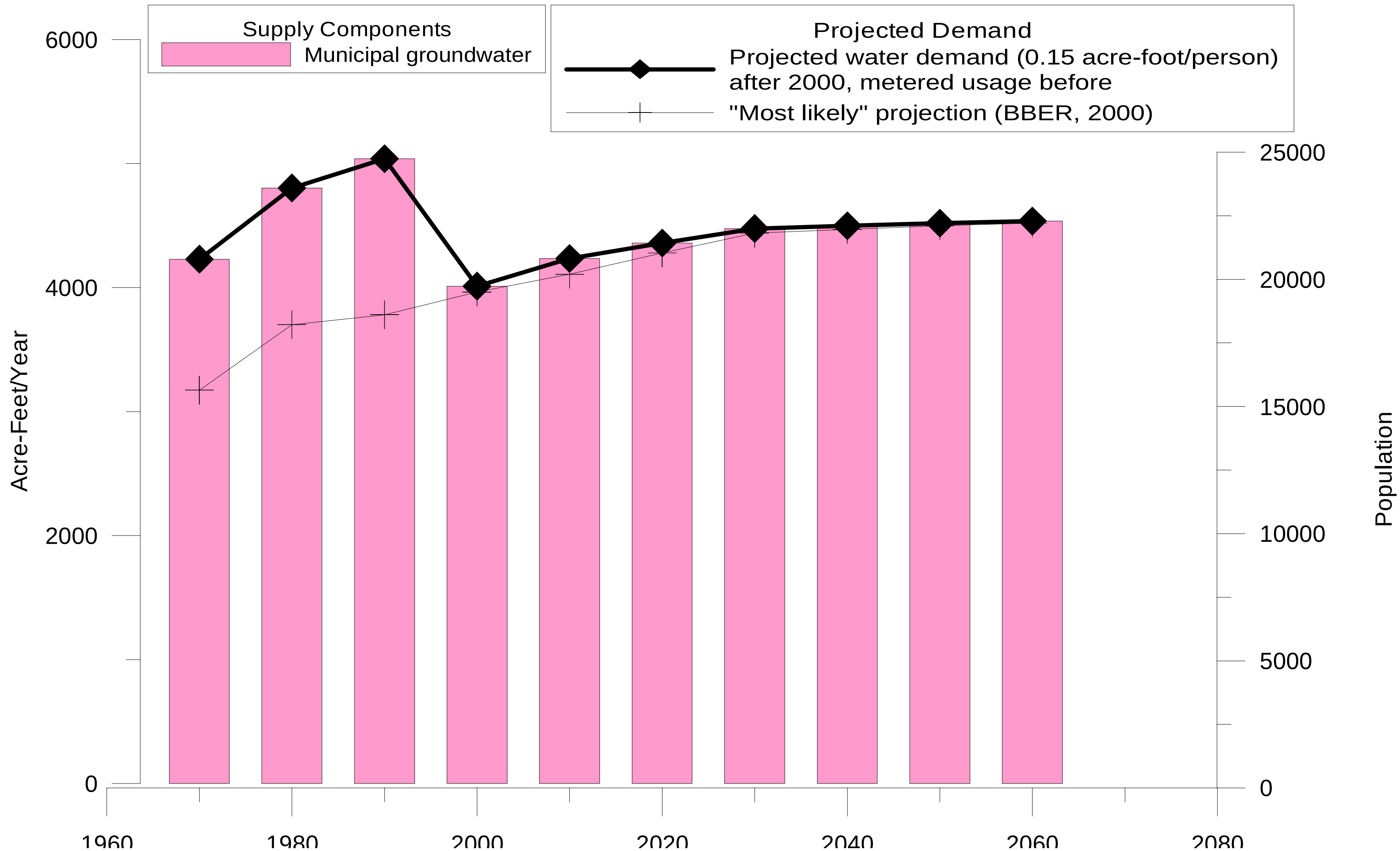
Figure 41



JEMEZ Y SANGRE REGIONAL WATER PLAN

Domestic and Municipal Water Demand in the Santa Clara Sub-Basin

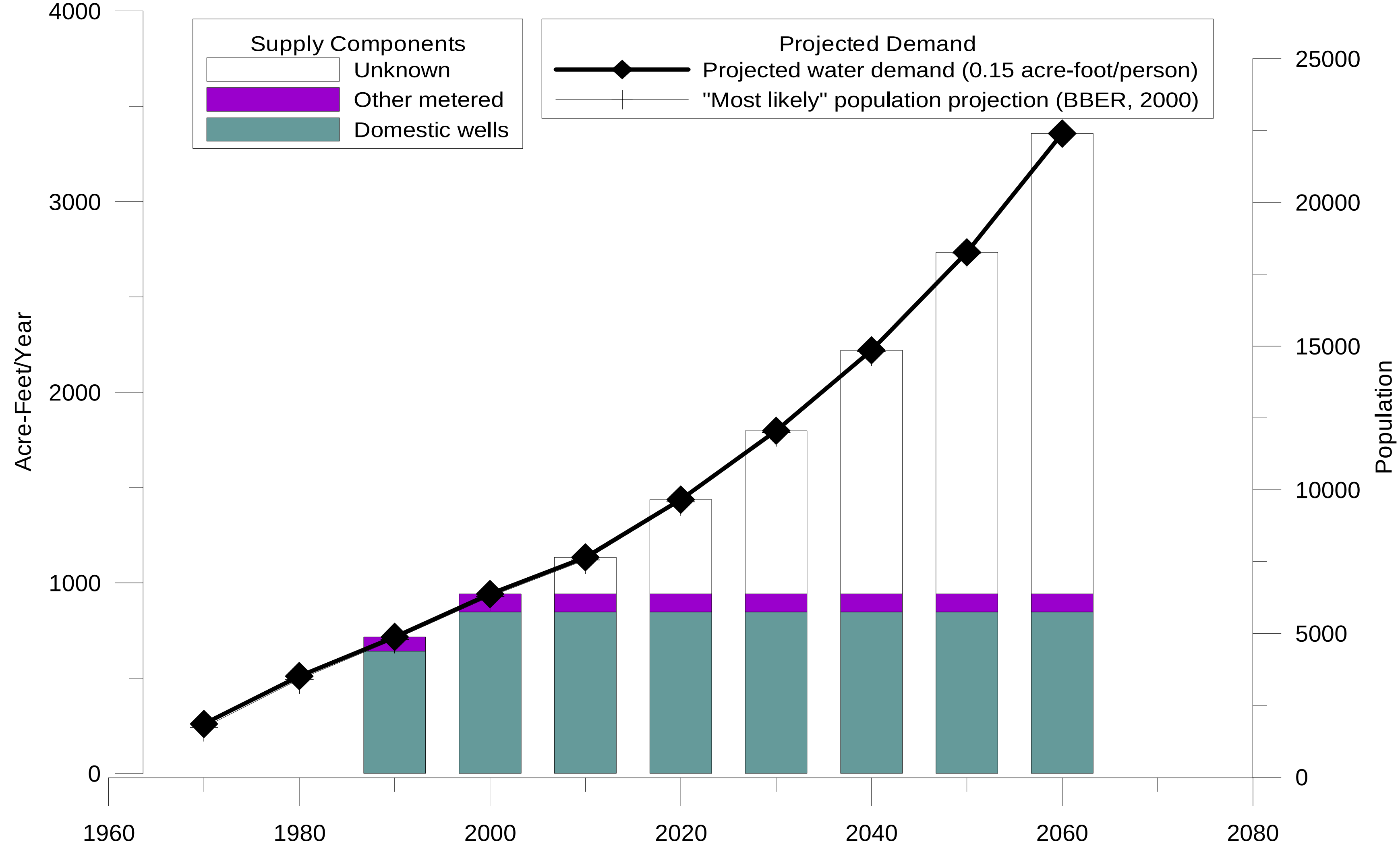
Figure 42



JEMEZ Y SANGRE REGIONAL WATER PLAN

Domestic and Municipal Water Demand in the Los Alamos Sub-Basin

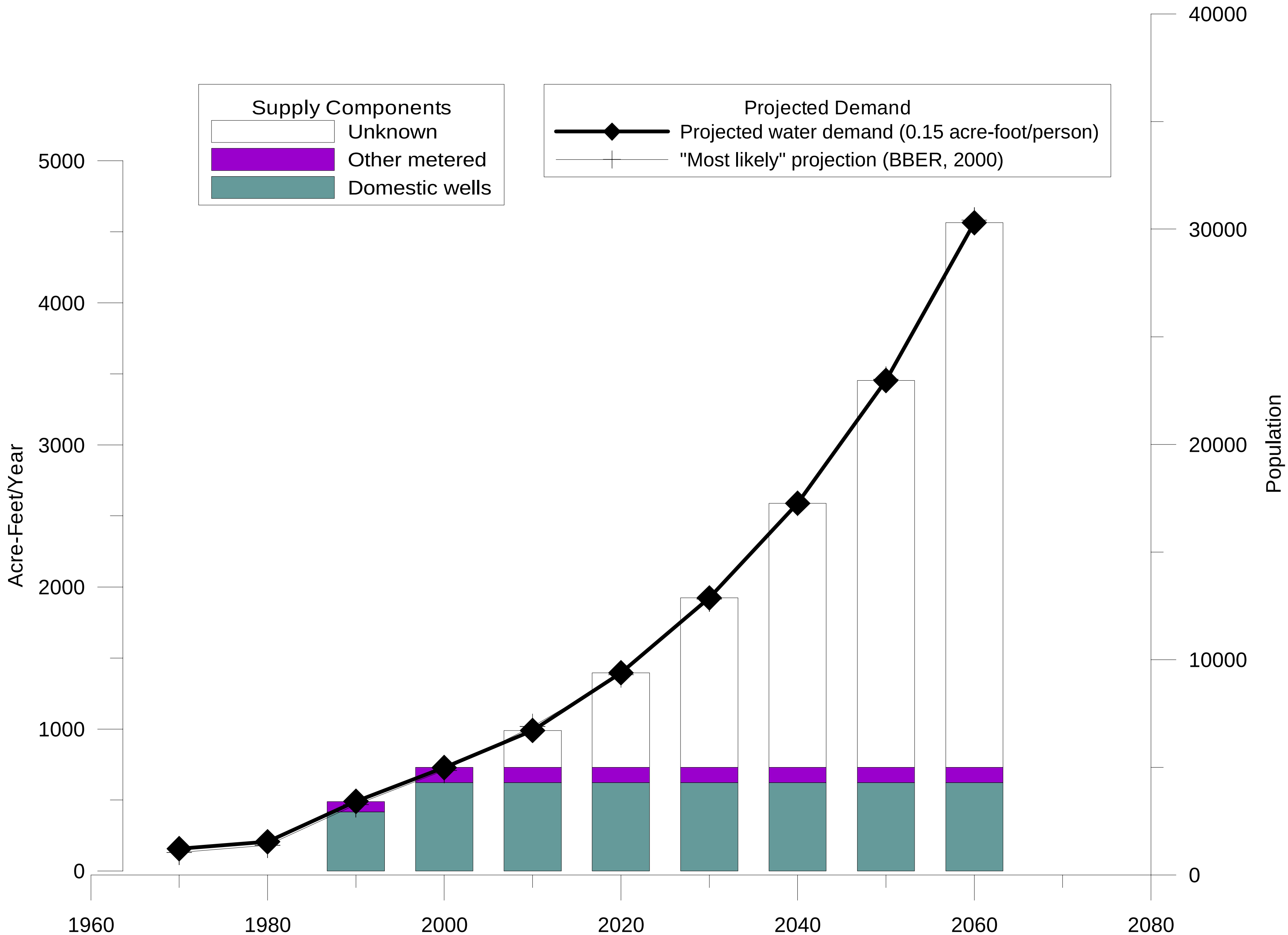
Figure 43



JEMEZ Y SANGRE REGIONAL WATER PLAN

Domestic and Municipal Water Demand in the Pojoaque-Nambe Sub-Basin

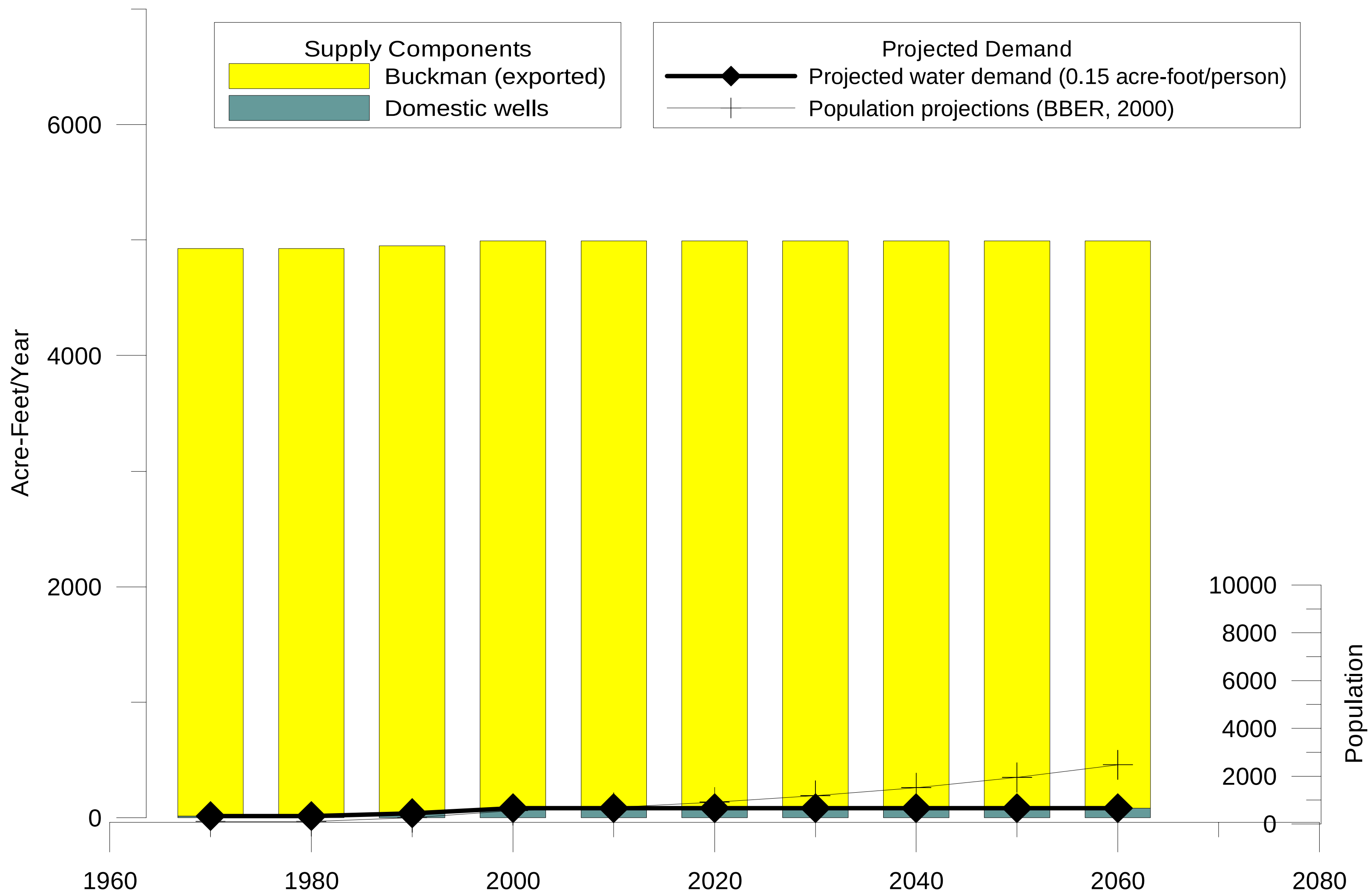
Figure 44



JEMEZ Y SANGRE REGIONAL WATER PLAN

Domestic and Municipal Water Demand in the Tesuque Sub-Basin

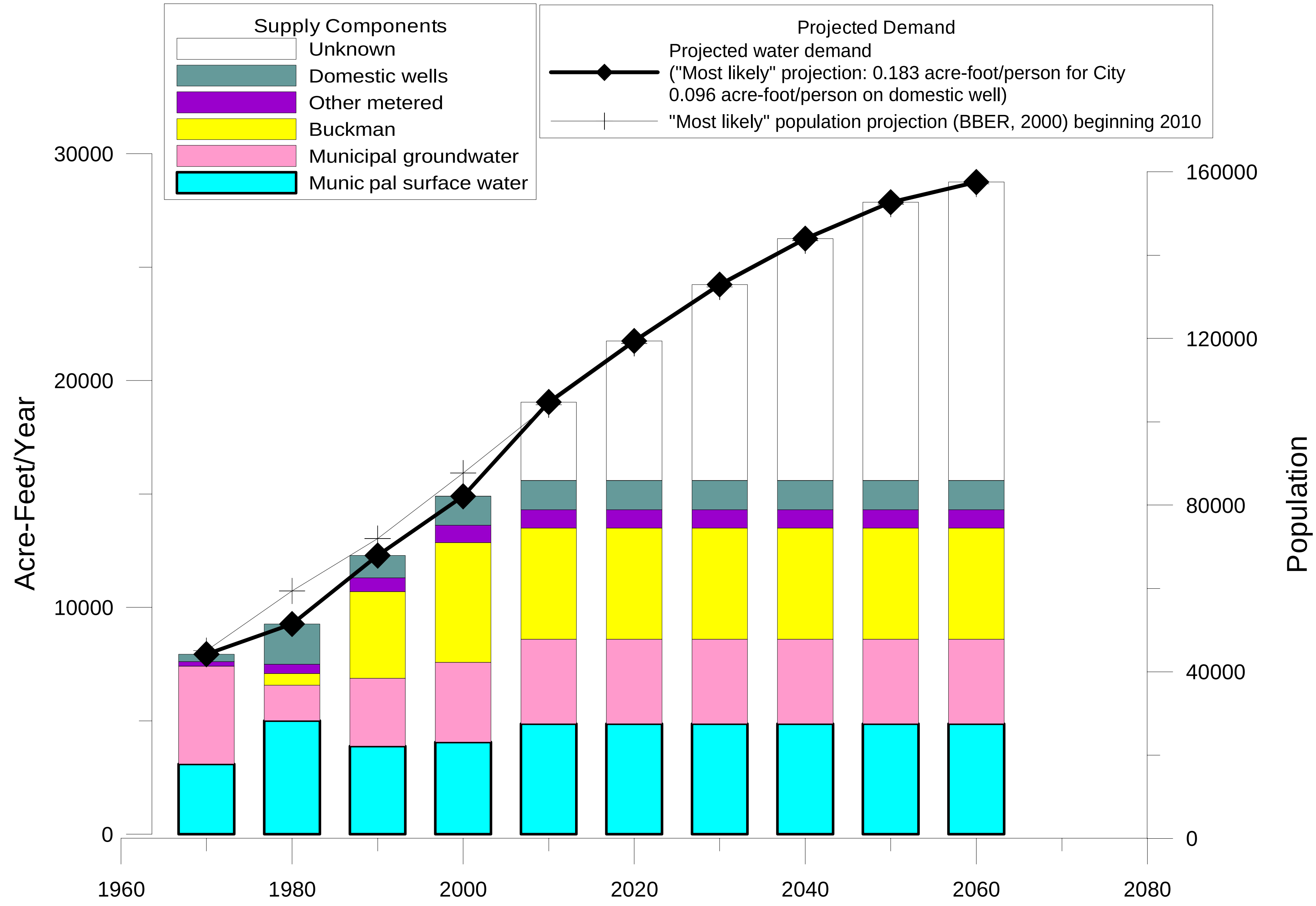
Figure 45



JEMEZ Y SANGRE REGIONAL WATER PLAN

Domestic and Municipal Water Demand in the Caja del Rio Sub-Basin

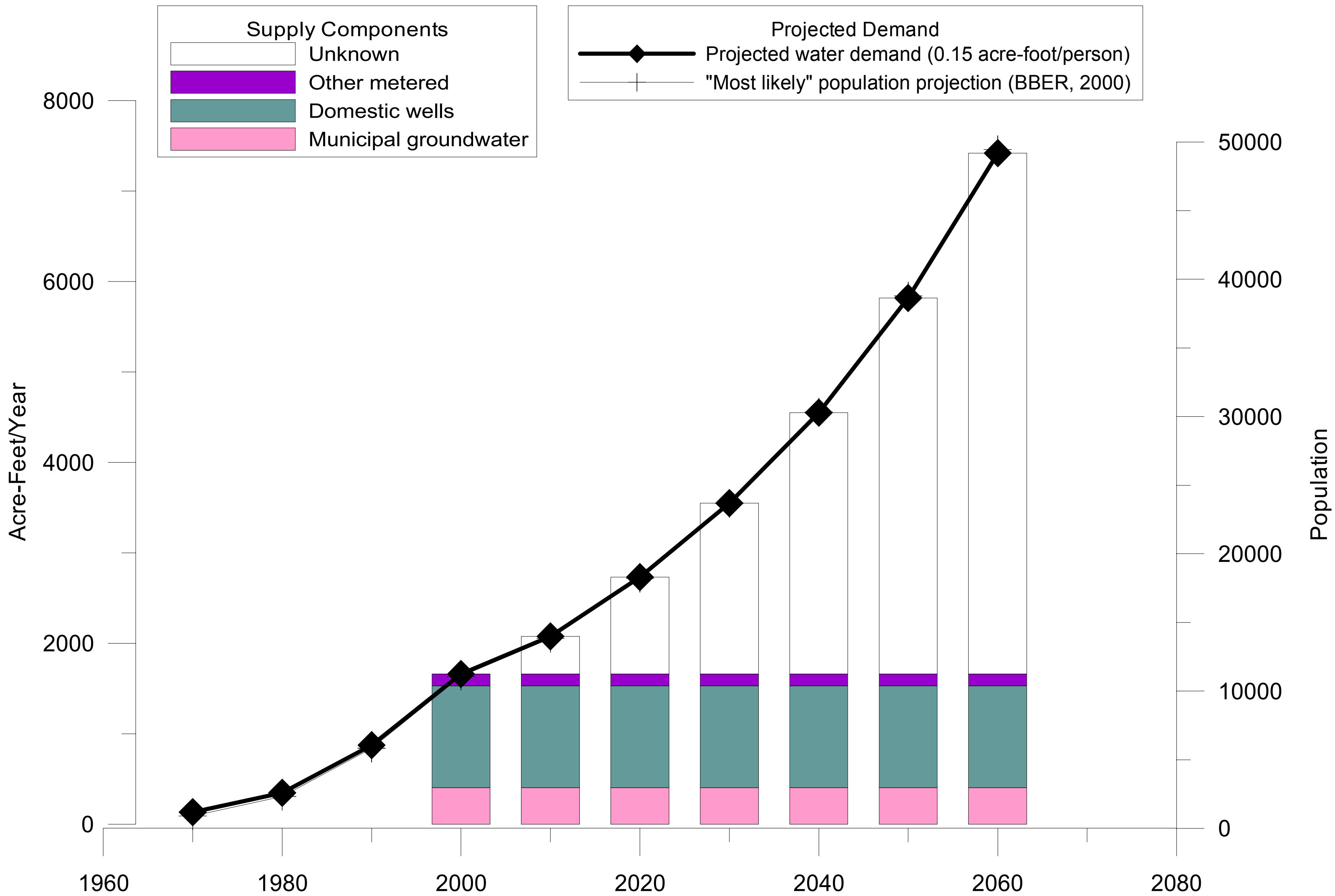
Figure 46



JEMEZ Y SANGRE REGIONAL WATER PLAN

Domestic and Municipal Water Demand in the Santa Fe River Sub-Basin

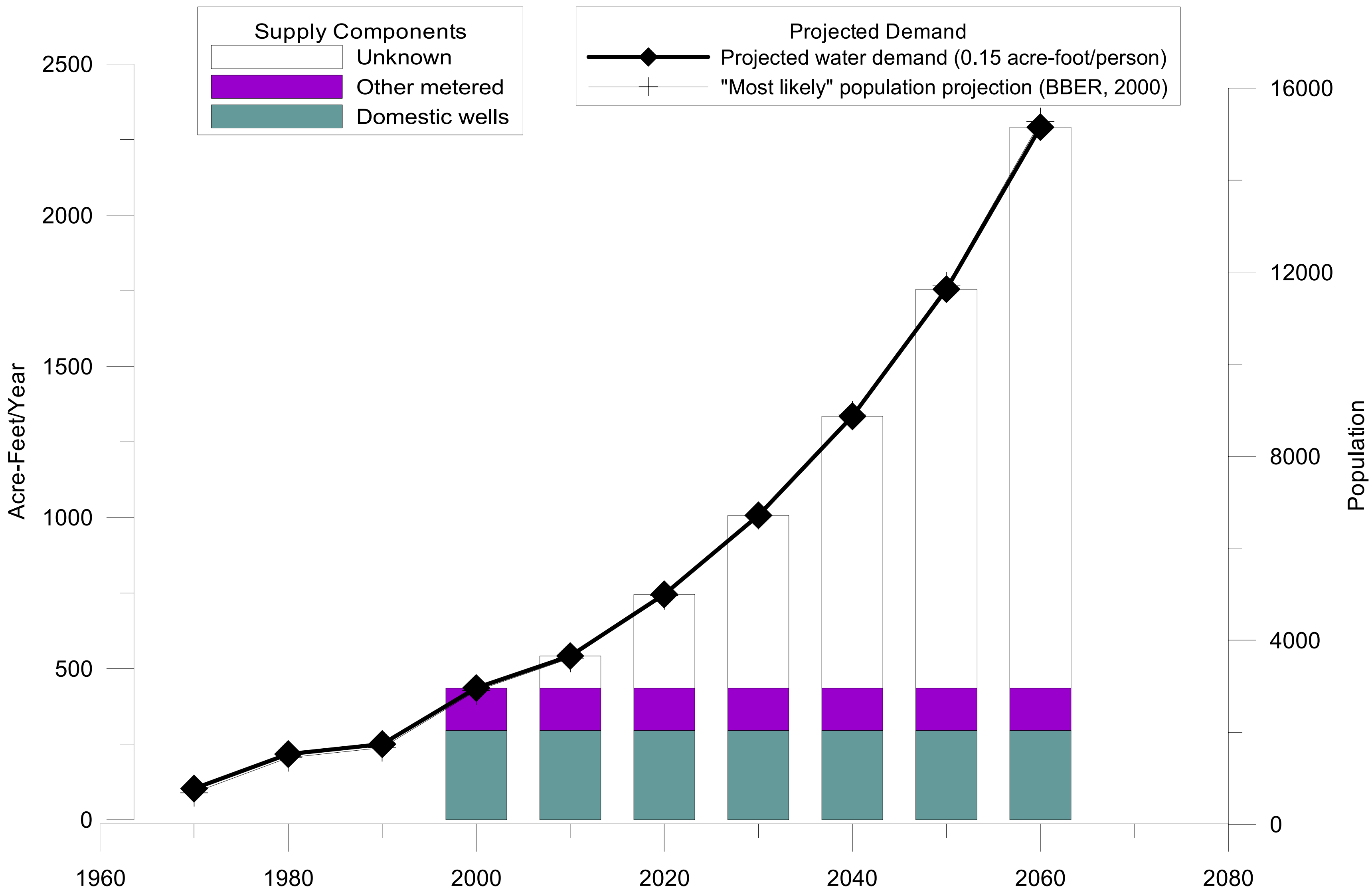
Figure 47



JEMEZ Y SANGRE REGIONAL WATER PLAN

Domestic and Municipal Water Demand in the North Galisteo Sub-Basin

Figure 48



JEMEZ Y SANGRE REGIONAL WATER PLAN

Domestic and Municipal Water Demand in the South Galisteo Sub-Basin

Figure 49

Table 24. Projected Supply/Demand Gap in 2060 for Each Sub-Basin

Sub-Basin	Projected Supply-Demand Gap in 2060 (acre-feet per year)
Velarde	474
Santa Cruz	3,392
Santa Clara	362
Los Alamos	0
Pojoaque-Nambe	2,416
Tesuque	3,834
Caja del Rio	288
Santa Fe River	13,150
North Galisteo Creek	5,756
South Galisteo Creek	1,856
Total	31,528